SCS
NATIONAL
ENGINEERING
HANDBOOK

SECTION 2

ENGINEERING PRACTICE STANDARDS

Part 1
ENGINEERING CONSERVATION PRACTICES

SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

April 1971

~~Current~~
~~Series~~

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

Washington, D. C. 20250

July 22, 1971

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NATIONAL ENGINEERING HANDBOOK NOTICE 2-101

This handbook notice cancels all previous National Engineering Handbook 2 Notices, specifically 2-1 through 2-21, and starts a new numbering series.

SCS National Engineering Handbook Section 2, Engineering Practice Standards, Part 1, Engineering Conservation Practices, has been revised and reprinted in its entirety. Revised copies are dated April 1971. All NEH Notices to the revised edition will be numbered in the 2-100 series.

Many of the practice standards and specifications guides have been broadened for greater use and emphasis in urban and other non-farm areas, pollution abatement, environmental enhancement, and fish and wildlife habitat improvement and maintenance.

Standards for Disposal Lagoons-359, and Holding Ponds and Tanks-425, have been added. Recreation Area Stabilization-561, has been changed to Heavy Use Area Protection-561.

Sufficient copies of the revised handbook are forwarded to replace those presently in use. The revised handbook should be put into use as soon as possible, and in no case later than January 1, 1972. Superseded handbooks should be destroyed.

Changes and additions will require that some state standards be revised to meet national minimums.

Copies of this notice should be given the same distribution as Section 2, National Engineering Handbook.

Norman A. Berg
Acting Administrator

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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Washington, D. C. 20250

August 31, 1972

NATIONAL ENGINEERING HANDBOOK NOTICE 2-103

This handbook notice amends Section 2, Engineering Practice Standards, 602 Level Terrace. Substitute revised standard 602 and discard the original one.

Copies of this notice should be given the same distribution as Section 2, National Engineering Handbook.

ACTING
JOHN T. PHELAN
Director
Engineering Division

Attachments

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SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

TERRACE, LEVEL

Definition

An earth embankment or a ridge and channel constructed across the slope at a suitable spacing with no grade.

Scope

This standard covers the planning and design of level terraces. It does not apply to Diversions.

Purpose

Level terraces are constructed to conserve moisture, to control erosion, and reduce pollution.

Conditions Where Practice Applies

Level terraces shall be constructed only on deep soils that are capable of absorbing and storing extra water without appreciable crop damage and in areas where the rainfall pattern is such that storage of rainfall in the soil, rather than removal, is practical and desirable.

They shall not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. In cultivated areas the topography must be such that farmable terraces can be constructed.

Design Criteria

Spacing

Level terraces shall be spaced to solve adequately the existing problem, whether it be the need for better moisture distribution, erosion control, or both. The maximum spacing of level terraces shall be determined by one of the following methods:

1. In all areas where data are available for applying the Universal Equation for predicting soil loss, the horizontal spacing of terraces shall not exceed the slope length determined for contour cultivation by using the allowable soil loss, the most intensive use expected for the land, and the expected level of management.

2. In other areas, the maximum vertical spacing shall be determined by the equation V.I. = 0.8s + y

   Where: V.I. = vertical interval in feet
   s = land slope in feet per 100 feet
   y = a variable with values from 1.0 to 4.0

   Values of y are influenced by soil erodibility, cropping systems, and crop management practices. The lower values are applicable to erosive soils with conventional tillage methods where little or no residue is left on the surface. The high value is applicable only to erosion resistant soils where no-plow or mulch tillage methods, which leave a large amount of residue (1.5 tons of straw equivalent) on the surface are used.

Vertical spacings determined by either of the above methods may be increased as much as 0.5 foot or 10 percent, whichever is greater, to provide better location or alignment, to miss obstacles in the field, to adjust for farm machinery, or to reach a satisfactory outlet.

The drainage area above the top terrace shall not exceed the area that would be drained by a terrace of equal length with normal spacing.

Alignment

Adjacent terraces shall be made as nearly parallel as practicable. Land smoothing, a moderate amount of cutting or filling along the terrace, and other methods shall be used as needed to improve alignment.

Capacity

The capacity of the terrace without overtopping shall be adequate to handle the runoff expected from a 10-year-frequency storm. The runoff volume of a 10-year-frequency, storm shall be considered in determining required storage capacity for closed-end terraces.

Cross Section

The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the machinery used. The ridge height as constructed shall include a reasonable settlement factor. The ridge shall have a minimum top width of 3.0 feet at the design height.

The minimum cross section shall meet the design dimensions. The elevation of the top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement.

Terrace End Closures

Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures will be used only on soils and slopes where the stored water will be absorbed by the soil without crop damage.

Where closed-end or partially closed-end terraces are specified, the end closures are a part of the terrace and must be made before the terraces are considered complete.

Terrace Lengths

For level terraces of given dimensions, the volume of water stored above the terrace is proportional to the length. Therefore, it is important that the length be held within reason so that damage in case of a break will be minimized. Terrace length shall not exceed 3,500 feet unless the channel is blocked at intervals to provide segments of this length.

Outlets

An adequate outlet shall be provided where terraces have open ends or partial end closures. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative outlets shall be installed before terrace construction, if needed, to insure establishment of vegetative cover in the outlet channel.

The design elevation of the water surface in the terrace shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Partial end closures shall not be more than half the effective height of the terrace ridge. Full end closures are those exceeding half of the effective height of the ridge. The cross section of end closures need not meet the terrace dimensions.

The opening of the outlet end of open-end level terraces shall have a cross section at least equal to that specified for the channel of the terrace.

Plans and Specifications

Plans and specifications for installation of Level Terraces shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE Washington, D. C. 20250

November 16, 1971

NATIONAL ENGINEERING HANDBOOK NOTICE 2-102

This handbook notice amends Section 2, Engineering Practice Standards, 432-B Irrigation Pipeline, Asbestos-Cement. On page 432-B-10, third paragraph, delete "maximum working pressure" and add "pipe classification, Type of pipe (I,II or III corresponding to the chemical requirements). This paragraph should read as follows:

> "Each length of pipe shall be marked with the manufacturer's identification, nominal size, pipe classification, Type of pipe (I,II or III corresponding to the chemical requirements) and date of manufacture."

Wm. B. Davey
Acting Administrator

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UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

NATIONAL ENGINEERING HANDBOOK
SECTION 2

STANDARDS FOR CONSERVATION PRACTICES REQUIRING ENGINEERING SERVICES

PREFACE

This handbook contains the engineering standards for conservation practices of the Soil Conservation Service. These standards have been prepared to establish the lowest limit of technical excellence permissible in the planning, design, and construction of these practices. The many variations in climate, soils, topography, or other physical features may require that they be strengthened when adapted for installation in a specific area.

Most of these standards have been in use for many years and except for minor changes are as published in the original draft of this section of the SCS National Engineering Handbook. However, the progress made in agricultural methods, and the knowledge gained by Soil Conservation Service experience and by research, require that standards for conservation practices be reviewed periodically and revised as necessary.

It is anticipated that the standards herein will continue to be revised as needs indicate, and the handbook has been arranged to permit such changes. The practice code for reporting purposes is the basis for the page numbering system, and standards may be added, removed, or amended without upsetting the page numbering.

Specifications for the actual installation of the various engineering conservation practices are to be developed in accordance with the standards herein. These specifications may be developed for an individual job, an administrative area, a land resource area, or for an entire state. Specifications guides are included for approximately one-half of the practices which list some of the items that should be considered in development of practice specifications.

Several standards specify the use of the American Society for Testing and Materials specifications or other standard material specifications. In accordance with Engineering Memorandum 64 (Rev. 1) the Lincoln EWP Unit will purchase and distribute all standard material specifications required. The latest revision of each specification will be distributed as soon as possible after it is printed.

April 1971

Some changes that have been made in this edition of Section 2 of the National Engineering Handbook are as follows:

1. Standards for all reportable conservation practices and measures involving engineering assistance have been included. Also included are certain non-reportable practices for which standards may be needed. The index indicates practice units to be reported.

2. Standards and specifications guides are separated in the handbook. Specifications guides bear the same number as the corresponding practice standard except that the number is preceded by the letter "S." This system permits (1) the direct use of these standards for state standards when they meet the needs for practices in the states and (2) the development of state specifications that can be set up under a separate cover if deemed advisable.

John T. Phelan

John T. Phelan
Director
Engineering Division

April 1971

CONSERVATION PRACTICES

REQUIRING

ENGINEERING SERVICES

Practice	Code
Access Road (Ft.)	560
Bedding (Ac.)	310
Clearing and Snagging (Ft.)	326
Dam, Diversion (No.)	348
Dam, Multiple Purpose (No. and Ac. Ft.)	349
Debris Basin (No.)	350
Dike (Ft.)	356
Disposal Lagoon (No.)	359
Diversion (Ft.)	362
Drain (Ft.)	606
Drain System Structure (Non-reportable)	608
Drainage Field Ditch (Ft.)	590
Drainage Land Grading (Ac.)	462
Drainage Main or Lateral (Ft.)	480
Floodwater Diversion (Ft.)	400
Floodwater Regarding Structure (No. and Ac. Ft.)	402
Floodway (Ft.)	404
Grade Stabilization Structure (No.)	410
Grassed Waterway or Outlet (Ac.)	412
Heavy Use Area Protection (Ac.)	561
Hillside Ditch (Ft.)	423
Holding Ponds and Tanks (No.)	425
Irrigation Canal or Lateral (Ft.)	320
Irrigation Ditch and Canal Lining (Ft.)	
Concrete, non-reinforced	358-A
Membrane, flexible	358-B
Galvanized steel	358-C
Irrigation Field Ditch (Ft.)	388
Irrigation Land Leveling (Ac.)	464
Irrigation Pipeline (Ft.)	
Aluminum tubing, plastic tape coated	432-A
Asbestos Cement	432-B
Concrete, non-reinforced	432-C
Plastic, High Pressure Underground	432-D
Plastic, Low Head Underground	432-E
Steel	432-F
Reinforced Plastic Mortar	432-G

April 1971

Practice	Code
Irrigation Pit or Regulating Reservoir (No.)	
Irrigation Pit	552-A
Regulating Reservoir	552-B
Irrigation Storage Reservoir (No. and Ac. Ft.)	436
Irrigation System, Sprinkler (No. and Ac. Ft.)	443
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Irrigation System, Tailwater Recovery (No.)	447
Irrigation Water Management (Ac.)	449
Land Clearing (Non-reportable)	460
Land Smoothing (Ac.)	466
Mole Drain (Non-reportable)	482
Obstruction Removal (Non-reportable)	500
Open Channel (Ft.)	582
Pipeline (Ft.)	516
Pond (No.)	378
Pond Sealing or Lining (Non-reportable)	
Flexible membrane	521-A
Soil dispersant	521-B
Bentonite	521-C
Cationic emulsion	521-D
Pumped Well Drain (Non-reportable)	532
Pumping Plant for Water Control (No.)	533
Recreation Land Grading and Shaping (Ac.)	566
Recreation Trail and Walkway (Ft.)	568
Regulating Water in Drainage Systems (Non-reportable)	554
Rock Barrier (Non-reportable)	555
Row Arrangement (Non-reportable)	557
Spoilbank Spreading (Non-reportable)	572
Spring Development (No.)	574
Streambank Protection (Ft.)	580
Stream Channel Stabilization (Ft.)	584
Structure for Water Control (No.)	587
Terrace, Basin (Ft.)	599
Terrace, Gradient (Ft.)	600
Terrace, Level (Ft.)	602
Terrace, Parallel (Ft.)	604
Trough or Tank (No.)	614
Vertical Drain (Non-reportable)	630
Waterspreading (Ac.)	640
Well (No.)	642

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

ACCESS ROAD

Definition

A road constructed as a part of a conservation plan to provide needed access.

Scope

This standard applies to roads constructed to provide access to farms, ranches, fields, conservation systems, structures, and recreation areas.

Purpose

To provide a route for travel, for moving equipment and supplies, and for providing access for proper operation and management of conservation enterprises.

Conditions Where Practice Applies

Where roads are needed to provide access from a township, county or state highway to the conservation enterprise, or to provide travelways within the planned area.

Design Criteria

Location

Roads will be located to serve the purpose intended, to facilitate the control and disposal of water, to utilize topographic features and to include scenic vistas where adaptable.

Gradient and Vertical and Horizontal Alignment

The gradient and alignment shall be adapted to the level of development of the conservation plan of which it is a part.

Width

The recommended minimum width of the roadbed is 14 feet for one-way traffic and 20 feet for two-way traffic. The two-way traffic width shall be increased approximately 4 feet for trailer traffic.

The recommended minimum tread width is 10 feet for one-way traffic and 15 feet for two-way traffic. The tread width for two-way traffic shall be increased approximately 5 feet for trailer traffic.

The recommended minimum shoulder width is 2 feet on each side of the tread width.

Side Slopes
All cuts and fills shall have side slopes that are stable for the soil or soil material involved.

Drainage
Culverts, bridges, or grade dips shall be provided at all natural drainageways. Design of these structures shall be in keeping with sound engineering practice for the class of vehicle or equipment used on the road.

Roadside ditches shall be adequate to provide surface drainage for the roadway and deep enough, as needed, to serve as outlets for subsurface drainage.

Erosion Control Measures
Needed erosion control measures shall be provided for road ditches cut slopes, fill slopes and cross drains.

Surfacing
Access roads shall be given a wearing course or surface treatment when required by traffic needs, climate, erosion control, or dust control. The type of treatment will depend on local conditions, available materials and the existing road base. Where these factors or the volume of traffic are not a problem, no special treatment of the surface is required. Sound engineering practice will be followed to insure that the road will meet the requirements of its intended use and maintenance requirements will be in line with operating budgets.

Intersection with Public Highways
Traffic safety shall be a prime factor in selecting the angle of intersection with public highways. Preferably the angle should be not less than 85 degrees and the clear sight distance to each side shall be not less than 300 feet where site conditions permit.

Plans and Specifications

Plans and specifications for installation of Access Roads shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-560-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

BEDDING

Definition

Plowing, blading, or otherwise elevating the surface of flat land into a series of broad, low ridges separated by shallow, parallel dead furrows.

Scope

This standard applies to the practice of shaping the land surface either as an initial construction operation or by farm equipment during farming operations.

Purpose

The purpose of bedding is to provide improved surface drainage at relatively low cost by establishing adjoining parallel beds or lands running in the direction of available natural slope. This is accomplished by moving soil toward centers of beds to form a series of ridges and dead furrows (troughs) which will accomplish one or more of the following: minimize water pondage, provide gradients for removing runoff, permit efficient operation of tillage and harvesting equipment, and eliminate sources for mosquito production.

Conditions Where Practice Applies

This practice applies to poorly drained areas of flat to nearly flat land usually having slowly permeable soils. It is generally used where potential production does not warrant more intensive drainage development. Soils must be of sufficient depth to provide a satisfactory root zone after bedding.

Design Criteria

Bedding shall be established to run with the available land slope in a manner which will provide drainage without harmful erosion. Bedding is usually established without detailed engineering surveys. Beds shall be shaped and cross-row ditches provided where required to provide free movement of water from the crown to the dead furrow. Crowns shall be developed so as to provide a cross slope of not less than 0.3 percent.

Crown heights, widths, and maximum lengths of beds shall be determined locally based on site conditions.

The recommended minimum tread width is 10 feet for one-way traffic and 15 feet for two-way traffic. The tread width for two-way traffic shall be increased approximately 5 feet for trailer traffic.

The recommended minimum shoulder width is 2 feet on each side of the tread width.

Side Slopes
All cuts and fills shall have side slopes that are stable for the soil or soil material involved.

Drainage
Culverts, bridges, or grade dips shall be provided at all natural drainageways. Design of these structures shall be in keeping with sound engineering practice for the class of vehicle or equipment used on the road.

Roadside ditches shall be adequate to provide surface drainage for the roadway and deep enough, as needed, to serve as outlets for subsurface drainage.

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Plans and Specifications

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SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

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Conditions Where Practice Applies

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Design Criteria

Bedding shall be established to run with the available land slope in a manner which will provide drainage without harmful erosion. Bedding is usually established without detailed engineering surveys. Beds shall be shaped and cross-row ditches provided where required to provide free movement of water from the crown to the dead furrow. Crowns shall be developed so as to provide a cross slope of not less than 0.3 percent.

Crown heights, widths, and maximum lengths of beds shall be determined locally based on site conditions.

Dead furrow channels may be shallow with side slopes either steep or flat based on the depth of soil, crops grown, and local construction and maintenance methods. Dead furrows shall be graded toward an outlet.

An outlet must be available or developed with sufficient capacity and depth to provide for removal of water from dead furrows.

Plans and Specifications

Plans and specifications for application of Bedding shall be in keeping with this standard and shall describe the essential requirements for proper application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

CLEARING AND SNAGGING

Definition

Removing snags, drifts, or other obstructions within the channel.

Scope

This standard covers the clearing of trees and brush, and the removal of sediment bars, drifts, logs, snags, boulders, piling, piers, headwalls, debris and other obstructions from the flow area of a natural or excavated channel.

Purpose

The purposes of this practice are: (1) to increase the flow capacity of the channel by improving flow characteristics, (2) to prevent bank erosion by eddies, (3) to reduce the forming of bars, and (4) to minimize the occurrence of ice jams.

Special attention will be given to maintaining or improving habitat for fish and wildlife where applicable.

Conditions Where Practice Applies

This practice is applicable to any channel or floodway where the removal of trees, brush and other obstructions is necessary to accomplish one or more of the purposes mentioned above. Where such removal will result in channel erosion, either the clearing and snagging shall not be done, or other practices, for the prevention of such erosion, shall be installed concurrently.

Design Criteria

The capacities of the channel, both before and after improvement, shall be determined by use of the Manning equation, using applicable values of the retardance factor, "n" for both conditions. The value of "n" used to determine channel capacity after improvement shall reflect the degree of maintenance expected in future years.

The area to be cleared and snagged shall include the perimeter of the channel, the flow area of the floodway, or both. Adjacent trees or other objects that may fall into the channel shall also be included. Clearing and snagging may be specified for other areas, including berms, for use as temporary disposal areas, travelways, or for planned conservation uses.

Channel Stability
Channel stability shall not be impaired by clearing and snagging. Criteria for determination of channel stability included in practice code 582, Open Channel, shall be complied with.

Plans and Specifications

Plans and specifications for installation of Clearing and Snagging shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-326-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DAM, DIVERSION

Definition

A structure built to divert part or all of the water from a waterway or stream into a different watercourse, an irrigation canal or ditch, or a waterspreading system.

Scope

This standard applies to structures of a permanent nature, constructed of materials having an expected life span consistent with the purpose for which the structure is designed. It does not include Diversion, Floodwater Diversion, Floodwater Retarding Structure or Grade Stabilization Structure.

Purpose

The purpose of a diversion dam is (1) to divert part or all of the water from a waterway in such a manner that it can be controlled and applied to a beneficial use, or (2) to divert periodic damaging flows from a watercourse to another watercourse having characteristics which reduce the damage potential of the flows.

Conditions Where Practice Applies

Where a diversion dam is needed as an integral part of an irrigation system or a water spreading system which has been designed to facilitate the conservation use of soil and water resources.

Where it is desirable to divert water from an unstable watercourse to a stable watercourse.

Where the water supply available is adequate for the purpose for which it is to be diverted.

Where the construction of a dam and the diversion of water are permitted by applicable State statutes and regulations.

Special attention will be given to maintaining or improving habitat for fish and wildlife where applicable.

Design Criteria

Materials

All materials to be used in construction of the diversion dam and appurtenances shall have the strength, durability and workability required to meet the installation and service conditions of the site.

Outlet Works

Where partial diversions are required the outlet works must provide for positive control of both maximum and minimum diversions consistent with the purpose for which the diversion is made. Where all the flow is to be diverted the outlet works must provide for safe diversion of all expected flows based on site conditions.

By-pass Works

The by-pass works must be capable of passing all flows needed to satisfy downstream priorities, and all flows in excess of diversion requirements. This may require a combination of orifices, wiers and gates designed to meet the requirements of the site.

Special Purpose Works

Where debris, bed load materials or sediments are present under flow conditions subject to diversion, provision shall be made to bypass or remove these materials which may be detrimental to the functioning of the outlet works, or to other portions of the works or areas to which diversion is made. This may involve the use of settling basins, debris traps, trash guards or sluiceways depending on the site conditions.

State Laws

Laws concerning water use and pollution abatement shall be complied with.

Plans and Specifications

Plans and specifications for installation of Diversion Dams shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-348-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DAM, MULTIPLE-PURPOSE

Definition

A dam, constructed across a stream or natural water course, with designed reservoir storage capacity specifically provided for two or more purposes such as floodwater retardation and irrigation water supply, municipal water supply and recreation, etc. Does not include Pond, Code 378.

Scope

This standard applies to dams which have separate storage allocations for two or more of the purposes listed below. (Sediment storage is not considered a separate purpose except under practice Code 350.)

Purpose

A multiple-purpose dam must provide distinct and specific storage allocations for 2 or more of the following purposes: (1) floodwater retardation, (2) irrigation, (3) fishing, hunting, boating, swimming or other recreational use, (4) improved environment or habitat for fish or wildlife, (5) municipal, (6) industrial, and (7) other uses. (A pond where multiple use is made of the same storage allocation is not considered a multiple-purpose dam.)

Conditions Where Practice Applies

This practice applies only to sites meeting all the following criteria:

1. Topographic, geologic, hydrologic and soil conditions at the proposed site are satisfactory for the development of a feasible dam and reservoir.

2. The sediment yield from the watershed is not excessive.

3. Water is available from a single or combined source of surface runoff, base flow, or from subsurface storage in sufficient quantity and adequate quality to satisfy the intended purposes.

Design Criteria

These design criteria are minimums for structures under the scope of this standard. More conservative design criteria should be used for structures approaching the purview of Engineering Memorandum No. 27. Multiple-purpose dams of above normal importance or of a hydraulic class and size under the purview of Engineering Memorandum No. 27, shall be designed to the standards set in that memorandum.

Foundation, Embankment and Spillway Requirements

All dams designed under this standard shall meet or exceed the foundation, embankment and spillway criteria as called for in SCS Engineering Standard for Pond, Code 378.

Floodwater Retarding Pool and Spillway Requirements

Dams with a floodwater retarding purpose shall meet or exceed the principle spillway and emergency spillway requirements of SCS Engineering Standard for Floodwater Retarding Structure, Code 402.

Outlet Works

Outlet works discharging releases for several purposes shall have adequate capacity to carry the peak flow resulting from the combined demands at any time. Outlet conduits and appurtenances shall be designed to criteria that are equal to or better than that called for in SCS Engineering Standard for Pond, Code 378.

Storage Requirements

The usable storage capacity shall be adequate for all purposes, considering seasonal variations in demand and the expected losses from seepage and evaporation.

Sediment Storage

Capacity in addition to that required for all other purposes must be provided to offset depletion by sediment accumulation for a period equal to the design life.

Type of Structures

All dams and appurtenances shall be designed to meet applicable SCS standards for the type and class of structure involved.

State Laws

Laws concerning water use and pollution abatement shall be complied with.

Plans and Specifications

Plans and specifications for installation of Multiple-Purpose Dams shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-349-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DEBRIS BASIN

Definition

A barrier or dam constructed across a waterway or at other suitable locations to form a silt or sediment basin.

Purpose

To preserve the capacity of reservoirs, ditches, canals, diversions, waterways, and streams; to prevent undesirable deposition on bottomlands and developed areas; to trap sediment originating from construction sites; and to reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural wastes, and other detritus.

Conditions Where Practice Applies

This practice applies where physical conditions or land ownership preclude the treatment of the sediment source by the installation of erosion control measures to keep soil and other material in place, or a debris basin offers the most practical solution to the problem.

Design Criteria

The capacity of a debris basin shall equal the volume of sediment expected to be trapped at the site during the planned useful life of the structures or improvements it is designed to protect. Where it is determined that periodic removal of debris will be practicable, the capacity may be proportionately reduced.

The design of dams, spillways and drainage facilities shall be in accordance with the standards for Ponds, Grade Stabilization Structure or Engineering Memorandum No. 27, as appropriate for the class and kind of structure being considered. Less conservative requirements may be used for small, temporary basins, that will be in place only during a short development or construction period and conditions so warrant.

In urban and built-up areas means of draining and maintaining a dry pool between periods of use shall be incorporated in the plans.

Safety measures to protect the public from the hazards of soft sediment and floodwater are to be established as conditions dictate.

Plans and Specifications

Plans and specifications for installation of Debris Basin shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-350-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DIKE

Definition

An embankment constructed of earth or other suitable materials to protect land against overflow from streams, lakes, and tidal influences; also to protect flat land areas from diffused surface waters.

Scope

This standard covers quality requirements for planning, designing, and constructing all dikes installed with Soil Conservation Service assistance to provide protection for land and property and includes dikes for floodways and wildlife improvement.

Dikes are divided into the following three classes:

Class I dikes include all dikes where one or more of the following conditions apply:

1. Where there is a possibility of loss of life should failure occur.

2. Where high value land or improvements are to be protected.

3. Where unusual or complex site conditions exist, such as organic soils outside the limits given for Classes II and III dikes.

4. Where the dike is designed to withstand more than 12 feet of water above normal ground surface, exclusive of crossings of sloughs, old channels, or low areas.

Class II dikes include embankments built to protect agricultural lands of medium to high capability with improvements generally limited to farmsteads and allied farm facilities.

Class III dikes are embankments which protect agricultural lands of relatively low capability or improvements of low value. These dikes are limited to low heads of water.

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Purpose

The purposes of dikes are to permit the improvement of land for agricultural production by preventing overflow and better utilizing drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments.

Conditions Where Practice Applies

The land to be protected must be suitable for the intended use. Locations shall be such that practical and economical construction, accessibility and maintenance can be obtained. Property lines, soils, open water, watershed characteristics, runoff, and adequate outlets for either gravity or pump drainage must be favorable.

Class I dikes are used to protect improved lands where inundation, erosion and scour, or sediment and debris may cause high property damage or loss of life.

Criteria for Class II dikes are applicable for all dikes not in Classes I or III.

Class III dikes are usually built where the spoil from excavated drainage channels is available. Class III dikes are to be used only on sites where:

1. The maximum design water stage against the dike is:

   a. 6 feet for mineral soils

   b. 4 feet for organic soils

   The maximum design water stage is the water elevation of the flood selected for design minus the elevation of the normal ground surface at the dike, excluding consideration of channels, sloughs, swales, and gullies.

2. Damages which are likely to occur from a dike failure are low.

Design Criteria - All Dikes

The location and design of dikes shall give careful consideration to the preservation of valuable fish and wildlife habitat and trees of significant value for wildlife food or shelter or for aesthetic purposes.

Where dike construction will adversely affect a significant fish or wildlife habitat, mitigation measures, acceptable to sponsors and concerned federal and state agencies, shall be included in the project.

Design Criteria - Class I Dikes

Location

Conditions to be considered in locating Class I dikes are suitable foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available for construction. No organic soil shall be allowed in the dike.

Height

Design height of dike. - The design height of the dike shall be the design high water depth plus 2 feet of freeboard, or 1 foot of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. Where failure may cause loss of life or extensive high-value property damage, the elevation of design high water shall be that associated with the stage of the 100-year frequency flood or of the maximum flood of record, whichever is the greater.

2. Where failure is unlikely to result in loss of life or extensive high-value property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year frequency flood, whichever is the greater.

3. In those situations where the dike is subject to stages from more than one stream, the above criteria shall be met for each stream or the combination of streams, whichever is the greater.

4. In those situations where the dike is subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide in order to determine the design high water depth.

Constructed height. - The design height of the dike shall be increased by the amount needed to insure that the design top elevation will be maintained after all settlement has taken place. This increase shall be not less than 5 percent.

Interior Drainage

Where inflow from the area to be protected by the dike may result in loss of life or extensive high-value property damage, provisions shall be included in the plans to protect the principal damage area. These features shall provide protection against a 10-day, 100-year frequency inflow hydrograph, plus an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

Where inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will insure the desired level of protection, whichever, is the greater.

Embankment and Foundation

The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. Design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, foundation and borrow pits are as follows:

Cross Section. - Minimum top width of Class I dikes shall be 10 feet for embankment heights of 15 feet or less and 12 feet for heights over 15 feet. Where maintenance roads are to be established on the dike top, "turnarounds" or passing areas shall be provided as needed.

Side slopes shall be determined from stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical where severe wave action is anticipated.

Banquettes. - Where dikes cross old channels or have excessively porous fills or poor foundation conditions, the land side toe shall be protected by a banquette or constructed berm. Such banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall be not less than 1 foot above mean ground and sloped away from the dike.

Where banquettes are to be used as a roadway for maintenance, "turnarounds" and passing areas shall be provided as needed.

Core Trench. - A core trench, or foundation cutoff, deep enough to extend into a relatively impervious layer, shall be used where foundation materials are sufficiently pervious to be subject to piping or undermining. Such core trench shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. Where pervious foundations are too deep to be completely penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

Ditches and Borrow Pits. - Land side ditches or borrow pits shall be located and designed so the hazard of piping through the foundation is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 feet in width, shall be left in the ditches at intervals not greater than 400-feet to form a series of unconnected basins.

For dikes where the design water depth is more than 5 feet, the land side ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design water line with the water side of the dike and the land side toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Drains. - A drainage system shall be used where necessary to insure safety of dikes. Toe drains, where used, shall be located on the land side and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed or permitted to remain without protection, closer to the land side toe of a dike than a distance 3 times design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Pipes and Conduits

Dikes shall be protected from scour at pump intakes and discharge locations by use of appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water where feasible, or be equipped with anti-seep collars.

All conduits through a dike below the design high water line shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps which are placed below the designed water line shall be equipped with a Dayton or similar coupling to

prevent vibration of the pumping plant being transmitted to the discharge conduits.

Vegetative Cover and Riprap
Where climatic conditions permit, a protective cover of grasses shall be established on all exposed surfaces of the dike. The dike shall be fenced where necessary to provide protection for the vegetation and for controlled grazing.

The seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with technical guides developed for the area.

Riprap shall be used where required to control erosion.

Design Criteria - Class II Dikes

Location
Conditions to be considered in locating Class II dikes are the same as for Class I dikes except the use of organic soils for Class II dikes is permissible for a surface layer on sides and top not over 1 foot thick.

Design Water Stage
The maximum design water stage permitted in this Class dike shall be 12 feet above normal ground level exclusive of crossings at channels, sloughs, and gullies.

The design and installation shall be based on engineering surveys and investigations made as provided for in applicable sections of the National Engineering Handbook. The stage and duration of high water for which protection is to be provided shall be determined from these investigations. Where the design water depth against dikes based on the required level of protection exceeds 4 feet, the design shall be based on the duration and measured or computed stages having a 4 percent or less chance of occurrence. If this degree of protection is determined to be uneconomic or not physically feasible, the design shall approach the 4 percent level as nearly as possible and planned fuse plug sections and other relief measures installed where appropriate.

Height
The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 feet or freeboard of 1 foot plus an allowance for wave height, whichever is greater. Estimates of wave height shall be based on local experience or on hydraulic studies.

The constructed height of the dike shall be the design height plus an allowance for settlement. The allowance for settlement shall be based on consideration of the soil material and the anticipated compaction but shall be no less than 5 percent of the design height.

Cross Section

The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Compacted Fills

Design Water Height Feet	Minimum Top Width Feet	Steepest Side Slope
0 - 6	6	1 1/2 : 1
6 - 12	8	2 : 1

Where soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated within the fill as follows:

Dumped Fills

Design Water Height Feet	Minimum Top Width Feet	Steepest Side Slope
0 - 6	6	2 : 1
6 - 12	8	2 1/2 : 1

Side slopes of 3 horizontal to 1 vertical on water side and 2:1 on land side may be used instead of 2 1/2:1 for both slopes.

The above cross sections shall be strengthened as required to provide additional protection against floods of long duration.

The top width shall be not less than 10 feet where a maintenance road is planned on top of the dike. "Turnarounds" or passing areas shall be provided as required on long dikes. Where the top width is greater than the minimum, the bottom width of the dike need not be increased above the minimum required even though the side slopes are steeper than for the standards given above. However, the side slopes shall be stable in all cases and not steeper than 1 1/2:1 on water side and 1:1 on land side.

The side slopes shall be 3:1 or flatter on the water side where severe wave action is expected, or where a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML are used in construction.

A banquette (or constructed berm) shall be placed to reinforce the land side toe where a dike crosses an old channel or where excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated.

The standard design shall include a top width of the banquette equal to or greater than the fill height of the dike above the top of the banquette. The banquette top shall be finished to an elevation not less than a foot above normal ground level and it shall be sloped toward the land side for drainage. The land side slope of the banquette shall not be steeper than the land side slope of the dike. Turnarounds and passing areas shall be established as needed on banquettes used for maintenance roads.

An alternate design of the banquette may be used where design is based on detailed site investigations, laboratory analyses, and adequate compaction is obtained.

Core Trench
A foundation cutoff or core trench shall be installed where there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and Borrow Pits
Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill Height	Minimum Berm Width
Under 6 feet	10 feet
Above 6 feet	15 feet

A land size ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike due to piping through the foundation.

For dikes where the design water depth is more than 5 feet, the land side ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design water line with the water side of the dike and the land side toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and Conduits

The dike shall be protected from scour at a pump intake and discharge by use of appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water where feasible or else equipped with anti-seep collars.

All conduits through the dike below the design high water line shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps which are placed below the designed water line shall be equipped with a Dayton or similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

Drains

Toe drains shall be used where necessary to insure safety of dikes. Toe drains, where used, shall be located on the land side, have a graded sand-gravel filter and be designed and installed in accordance with Soil Conservation Service standards for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection, closer to the land side toe of a dike than a distance 3 times design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Vegetative Cover and Riprap

An adequate protective cover of grasses shall be established on all exposed surfaces of the dike where in the judgment of the responsible technician this is necessary to protect against erosion by flood flows, wave action or from rainfall and runoff on the dike. The dike shall be fenced where necessary to provide protection for the vegetation and for controlled grazing.

The seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with technicial guides developed for the area.

Riprap shall be used and placed according to SCS standards where required to control erosive velocities.

Design Criteria - Class III Dikes

The design criteria shall be based on site conditions as determined from engineering surveys and investigations. The design shall meet state-approved Service standards for top width, side slopes, freeboard, and berm width.

The berm widths shall be adequate to prevent undermining of the dike.

Dikes constructed from channel spoil may be shaped to an approximate cross section. However, the spoil must be of required height and left so that sloughing will not impair the design section.

Dikes of organic soils shall be installed in accordance with the principles given in Chapter 8, Section 16, National Engineering Handbook.

Maintenance - All Dikes

All dikes must be adequately maintained to the required shape and height. Erosion controlling vegetation shall be established on dikes as required by climatic conditions and the need for protection against wave action. The maintenance of dikes must include periodic removal of woody vegetation which may become established on the embankment. Design of the project shall include provisions for maintenance access.

Plans and Specifications

Plans and specifications for construction of Dikes shall be in keeping with this standard and shall describe the requirements for construction of the practice to achieve its intended purpose. See page S-356-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DISPOSAL LAGOON

Definition

An impoundment made by constructing an excavated pit, dam, embankment, dike, levee or combination of these for biological treatment of organic waste. (This standard does not include holding ponds and tanks.)

Scope

This standard establishes the minimum acceptable quality for design construction, and maintenance of disposal lagoons located to serve predominantly rural or agricultural areas.

Purpose

Lagoons are constructed to biologically decompose organic waste by aerobic or anaerobic organisms.

Conditions Where Practice Applies

General
This practice applies where there is need for a facility to process concentrated organic waste, reduce sources of pollution, minimize health hazards and improve the local environment.

State Law
All state and local laws, rules and regulations governing use of disposal lagoons shall be strictly adhered to. The owner or operator must be responsible for securing necessary permits where required.

Design Criteria

Types
Disposal lagoons are of three types depending on the reaction that takes place--anaerobic, aerobic or a combination of both. Anaerobic lagoons are septic and will give off odors. Most structures for treatment of animal wastes are of this type due to the volume of material to be handled. Aerobic lagoons, when properly designed and managed, are relatively odor free, but require greater surface area per animal unit and may require aerating facilities at certain periods of the year.

Location
The site shall be located adjacent to or near the source of waste. It shall be as far from inhabited dwellings as practical with a minimum distance of 300 feet. Locate where summer prevailing winds will carry odors away from the house and public areas.

The lagoon shall be located and constructed so that uncontrolled run-off from outside drainage areas does not enter the lagoon.

Soil and Foundation
Locate on soils of low permeability or soils suitable for sealing. Prevent contamination of underground water table by avoiding soils with high water table, sandy or gravelly soils, or shallow soils, over-fractured or cavernous rock.

Water Supply
Sufficient water supply shall be available to fill the lagoon before loading and to maintain it after operation starts.

Temperature
The temperature of lagoon waters affects the rate of biological activity. There is essentially no activity in anaerobic lagoons with water temperatures below 45° F. They operate best at temperatures of 70° - 130° F. Ice and snow cover on aerobic lagoons reduces sunlight penetration and associated algae growth necessary for providing oxygen. Under such conditions there is limited biological activity in such lagoons. Loading rates should be less and detention times greater in colder climates than in warmer climates.

Composition of Wastes
Table 1. Composition of Livestock and Poultry Wastes, lists daily production of manure, BOD_5 and volatile solids per animal. This table may be used as a guide to lagoon design, but local or on-site determinations should be utilized where possible. Production of manure, BOD_5 and volatile solids varies considerably depending on feed, climate, size of animal and production methods. The maximum weight of animals which may utilize a lagoon at any one time should be the basis for estimating waste production.

Aerobic Lagoon Loadings
Aerobic lagoons are designed on the basis of daily BOD_5 loading per acre of surface area. Figure 1 shows loadings generally recommended by states[1/]. Allowable loadings for aerobic disposal lagoons shall be in accordance with state requirements.

[1/] Canter, L.W. and A.J. Englande, Jr., October 1970. Journal, Water Pollution Control Federation

Anaerobic Lagoon Loadings

Anaerobic lagoons are designed on the basis of daily BOD_5 or volatile solids per 1000 cubic feet of lagoon volume. Figure 2 shows loadings generally recommended by zones of the country. Allowable loadings for anaerobic disposal lagoons shall be in accordance with state requirements.

Earth Embankment

Top Width - The minimum top width shall be 8 feet.

Side Slopes - The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical.

Freeboard - The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the lagoon.

Allowance for Settlement - The design height of the embankment shall be increased by the amount needed to insure that the design top elevation will be maintained after settlement has taken place. This increase shall not be less than 5 percent.

Depth

The minimum depth of liquid storage space shall be 6 feet for anaerobic lagoons and 2 feet for aerobic lagoons. Maximum depths for anaerobic lagoons are those dictated by the site and needs. Maximum depth for aerobic lagoons shall be 5.0 feet.

Bottom

The bottom of aerobic lagoons shall be approximately level to prevent formation of septic pockets.

Edges

The edges of the lagoon below the planned water line shall be deepened to a stable slope as steep as soil conditions will permit to reduce areas of shallow water and to inhibit weed growth.

Inlet

Where freezing is not a problem, an open inlet consisting of a concrete ditch may be used. Where freezing is a problem, the inlet shall consist of a pipe with a minimum diameter of 6 inches with a minimum slope of 1 percent. The inlet pipe should terminate near the center of the lagoon and far enough below the surface to protect from freezing or other protective measures provided. Access to the pipe for rodding should be provided in case of blockage.

Outlet

An overflow pipe shall be installed so that water is discharged from a minimum of 6 inches below the surface when the maximum water level is reached. A vented elbow or turndown on the outlet pipe entrance may be used for this purpose.

Effluent Disposal
The effluent from lagoons should be retained on farm or ranch property. It may be further treated by additional lagoons or held in holding ponds prior to final disposal. Final disposal may be by evaporation or by liquid spreading systems, irrigation systems or other land application measures. The disposal area should have proper soils and cover to prevent pollution of groundwater. Application rates should be sufficiently low to prevent surface runoff and volume of effluent applied should be such that nutrients are utilized by the plant cover. Lagoon effluent shall not be allowed to discharge to surface waters unless the owner determines through the state water pollution control agency that such discharge will not be in violation of established water quality standards.

Settling Tank
A settling tank may be provided between the lagoon and waste source to trap solids which will not completely decompose. This may be a concrete tank which can be emptied periodically or excavated areas which can be cleaned periodically with a front-end loader. Where excavated areas are used, a minimum of two will be required so that one may be dried and cleaned while the other is functioning. A minimum of 7 to 10 days storage should be provided in the settlement tank based on a minimum requirement of 6 gallons per day per horse or cow and 1 gallon per day per sheep or hog.

Protection
Where the location is such as to create a safety hazard the lagoon should be fenced and warning signs posted to prevent children and others from using the lagoon for purposes other than intended.

Vegetation
The embankment and surrounding areas shall be vegetated to protect from erosion.

Operation and Maintenance
Loading - The lagoon should be filled with water to the minimum depth. The first loading in summer shall be gradual. If the first loading is made in the winter, loading rate is not important as reaction will be slight before warmer weather occurs. Daily loading results in best operations. If intermittent loading is necessary, the minimum depth should be maintained by addition of water.

Floating Material - Provisions shall be made to keep bedding material, straw, oil and other floating material out of the lagoon. Grass clippings from mowing operations should be removed from the lagoon.

Plans and Specifications

Plans and specifications for installation of Disposal Lagoons shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

TABLE I

COMPOSITION OF LIVESTOCK AND POULTRY WASTES

(production in pounds per day)

Animal	Manure	BOD_5	Volatile Solids
Dairy Cattle (1200-1500 lbs.)	100	2.0	8
Beef Cattle (800-1000 lbs.)	75	1.5	7
Horses (1000 lbs.)	56	1.4	8
Sheep (100 lbs.)	4.0	0.25	0.86
Hogs (150 lbs.)	8.5	0.32	0.60
Poultry (4 lbs.)	0.25	0.015	0.042

Figure I

STABILIZATION POND DESIGN

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

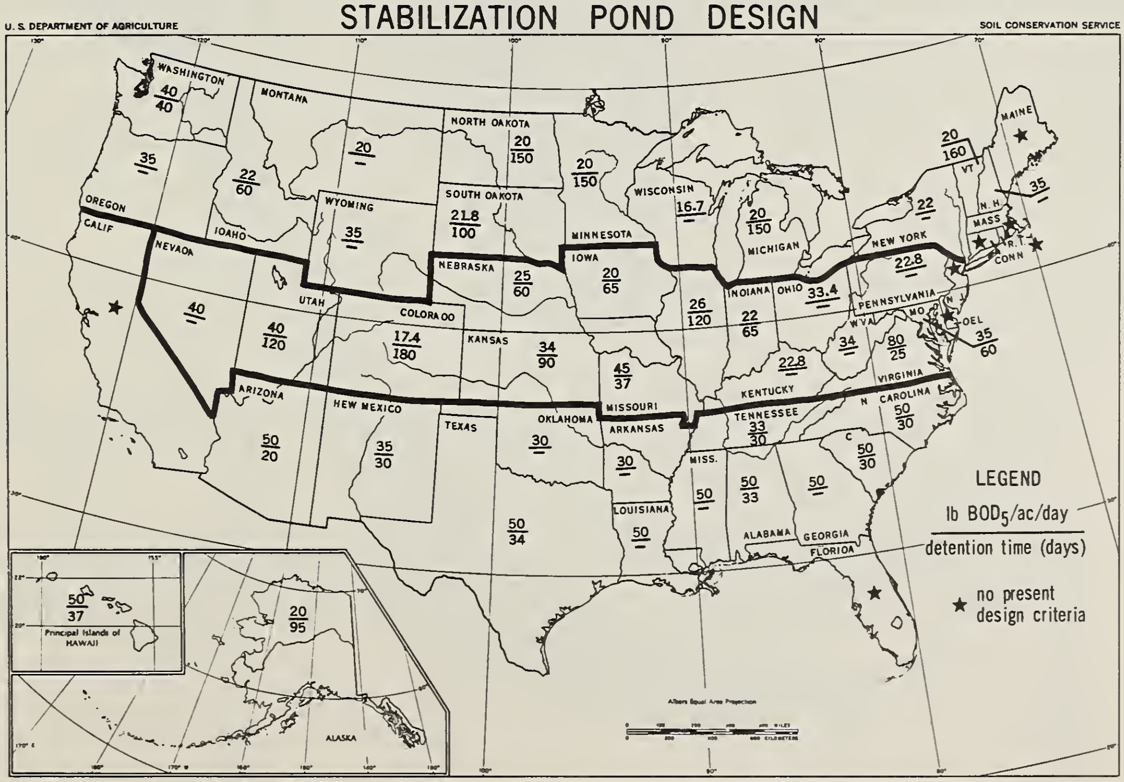
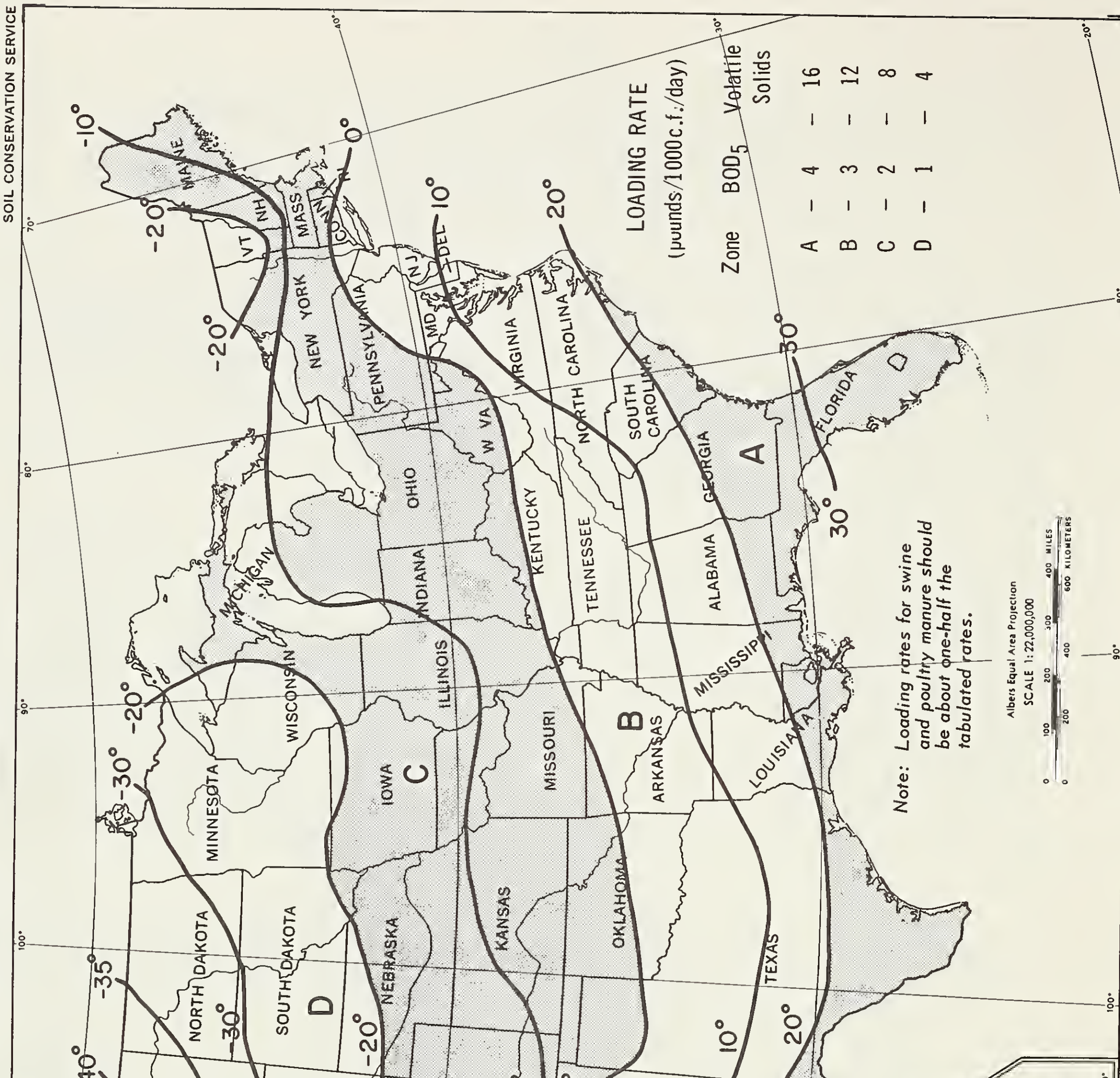


Figure 2

ANAEROBIC LAGOON LOADING RATES BY ZONES

DAILY MEAN TEMPERATURES OCCURRING ABOUT ONCE IN 13 YEARS
(FROM ASHRAE 1963 GUIDE)



SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DIVERSION

Definition

A channel with a supporting ridge on the lower side constructed across the slope.

Scope

This standard covers the installation of all diversions except floodwater diversions.

Purpose

The purpose of this practice is to divert water from areas where it is in excess to sites where it can be used or disposed of safely.

Conditions Where Practice Applies

This practice applies to sites where:

1. Runoff from higher lying areas is damaging cropland, pastureland, farmsteads, or conservation practices such as terraces or stripcropping.

2. Surface and shallow subsurface flow is damaging sloping upland.

3. Runoff is available for diversion and use on nearby sites.

4. Required as a part of a pollution abatement system, or to control erosion and runoff on urban or developing areas and construction sites.

Diversions shall not be substituted for terraces on land requiring terracing for erosion control.

Diversions are not usually applicable below high sediment producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversions.

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Design Criteria

Capacity
Diversions protecting agricultural land and those that are part of a pollution abatement system must have the capacity to carry the peak runoff from a 10-year-frequency storm as a minimum, with a freeboard not less than 0.3 foot. Diversions designed to protect urban areas, buildings and roads, and those designed to function in connection with other structures, shall have enough capacity to carry the peak runoff expected from a storm frequency consistent with the hazard involved.

Cross Section
The channel may be parabolic, V-shaped, or trapezoidal. The diversion shall be designed to have stable side slopes. The ridge height shall include a reasonable settlement factor. The ridge shall have a minimum top width of 4 feet at the design elevation. The minimum cross section shall meet the specified dimensions. The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement.

Location
Diversion location shall be determined by outlet conditions, topography, land use, cultural operations, soil type, and length of slope.

A diversion in a cultivated field must be aligned so as to permit the use of modern farming equipment.

Protection Against Sedimentation
When movement of sediment into the channel is a significant problem, a vegetated filter strip shall be used except where soil and/or climate preclude the use of such strips. In this latter case the design shall include extra capacity for sediment and be supported by supplemental structures, cultural or tillage practices or special maintenance measures.

Outlets
Each diversion must have an adequate outlet. The outlet may be a grassed waterway, vegetated or paved area, grade stabilization structure, stable watercourse, or tile outlet. In all cases the outlet must convey runoff to a point where outflow will not cause damage. Vegetative outlets shall be installed before diversion construction, if needed, to insure establishment of vegetative cover in the outlet channel.

The design elevation of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Plans and Specifications

Plans and specifications for installation of Diversion shall be in keeping with the standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DRAIN

Definition

A conduit, such as tile, pipe, or tubing, installed beneath the ground surface and which collects and/or conveys drainage water.

Purpose

A drain may serve one or more of the following purposes:

1. Improve the environment for agriculture by lowering the water table.

2. Intercept and prevent water movement into a wet area.

3. Relieve artesian pressures.

4. Remove surface runoff.

5. Facilitate leaching of saline and alkali soils.

6. Serve as an outlet for other drains.

7. Provide ground water regulation and control for subirrigated areas.

Conditions Where Practice Applies

Drains are used in areas having a high water table where benefits of lowering or controlling groundwater or surface runoff justify the installation of such a system.

All lands to be drained shall be suitable for the use intended within their capabilities after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system. The drainability and treatment of saline and alkali soils shall be considered where this is a problem.

An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity and quality of effluent to be disposed of with consideration of possible damages above or below the point of discharge that might involve legal actions under state laws.

Design Criteria

The design and installation shall be based on adequate surveys and investigations.

Required Capacity of Drains
The required capacity shall be determined by one or more of the following:

1. A suitable drainage coefficient including capacity required to dispose of surface water entering through inlets.

2. Yield of groundwater based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.

3. Survey and comparison of the site with other similar sites where subsurface drain yields have been measured.

4. Measurement of the rate of subsurface flow at the site.

5. The application of Darcy's law to lateral or artesian subsurface flow.

6. Estimates of lateral or artesian subsurface flow.

Size of Drain
The size of drains shall be computed by applying Manning's formula. The required capacity shall be determined as provided above and the size computed based on one of the following assumptions:

1. Hydraulic grade line parallel to the bottom grade of the drain with the drain flowing full at design flow.

2. The drain flowing part full where a steep grade or other condition requires excess capacity.

3. Drain flowing under pressure with hydraulic grade line set by site conditions on a grade which differs from that of the drain. This procedure shall be used only where surface water inlets or nearness of the drain to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

The minimum size of drain shall be equivalent to a 4-inch diameter pipe.

Depth, Spacing, and Location
The depth, spacing, and location of the drain shall be based on site conditions including soils, topography, groundwater conditions, crops, outlets, and saline and alkaline conditions.

The minimum depth of cover over subsurface drains in mineral soils shall be 24 inches. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet, or sections laid through minor depressions where the drain is not subject to damage by frost action or equipment travel, and where site conditions justify specifying other depths.

The minimum depth of cover in organic soils shall be 30 inches for normal field levels as defined above, after initial subsidence. Structural measures shall be installed where feasible to control the water table level in organic soils within the optimum range of depths.

Minimum Velocity and Grade
In areas with no siltation hazard the minimum grades shall be based on site conditions. Where it is determined that a hazard exists, a velocity of not less than 1.4 feet per second shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for prevention of siltation by filters or collection and removal of silt by use of silt traps as specified in the plans.

Maximum Grade and Protection
On sites where topographic conditions require the use of drain lines on grades steeper than two percent or where design velocities will be greater than indicated in the table below, special measures shall be used to protect the drain. These measures shall be specified for each job based on the particular conditions of the job site. The protective measures shall include one or more of the following:

1. Use only drains that are uniform in size and shape and with smooth ends.

2. Lay the drains so as to secure a tight fit with the inside diameter of one section matching that of the adjoining sections.

3. Wrap open joints with tar impregnated paper, burlap, or special filter material such as plastic or fiber-glass fabrics.

4. Select the least erodible soil available for blinding.

5. Tamp blinding material carefully around the drain before backfilling.

6. Seal joints or use a watertight pipe.

7. For continuous pipe or tubing with perforations, completely enclose the pipe with filter material of plastic, fiber glass, or properly graded sand and gravel.

Maximum Permissible Velocity in Drains Without Protective Measures

Soil Texture	Velocity -- ft/sec
Sand and Sandy Loam	3.5
Silt and Silt Loam	5.0
Silty Clay Loam	6.0
Clay and Clay Loam	7.0
Coarse Sand or Gravel	9.0

Materials for Drains

"Drains" include conduits of clay, concrete, bituminized fiber, metal, plastic, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements of the site. Current specifications as listed below, or as included in this standard, shall be used in determining the quality of the conduit.

The following specifications cover the products currently acceptable for use as drains or for use in determining quality of materials used in drainage installations:

Type	Specification
Clay drain tile	ASTM[1] C 4
Clay drain tile, perforated	ASTM C 498
Clay sewer pipe, standard strength	ASTM C 13
Clay pipe, extra strength	ASTM C 200
Clay pipe, perforated, standard and extra strength	ASTM C 211
Clay pipe, testing	ASTM C 301
Concrete drain tile	ASTM C 412
Concrete pipe for irrigation or drainage	ASTM C 118
Concrete pipe or tile, determining physical properties of	ASTM C 497
Concrete sewer, storm drain, and culvert pipe	ASTM C 14

[1] American Society for Testing and Materials, 1916 Race Street Philadelphia, Pa. 19103

Type	Specification
Reinforced concrete culvert, storm drain, and sewer pipe	ASTM C 76
Perforated concrete pipe	ASTM C 444
Portland Cement	ASTM C 150
Asbestos-cement nonpressure sewer pipe	ASTM C 428
Asbestos-cement perforated underdrain pipe	ASTM C 508
Asbestos-cement pipe, testing	ASTM C 500
Bituminized fiber, perforated drainage pipe	Federal Spec.[2] SS-P-358
Homogeneous perforated bituminized fiber pipe for general drainage	ASTM D 2311
Homogeneous bituminized fiber pipe, testing	ASTM D 2314
Laminated-wall bituminized fiber perforated pipe for agricultural, land, and general drainage	ASTM D 2417
Laminated-wall bituminized fiber pipe, physical testing of	ASTM D 2315
Styrene rubber plastic drain and building sewer pipe and fittings	ASTM D 2852
Perforations, if needed, are to be as specified in Fed. Spec. SS-P-358 or ASTM D 2311	
Plastic drainage tubing, corrugated	Specifications on page 606-11
Pipe, corrugated, (aluminum alloy)	Federal Spec. WW-P-402
Pipe, corrugated, (iron or steel, zinc coated)	Federal Spec. WW-P-405

Clay Tile - These specifications may be modified as follows: Where clay tile will not be subject to freezing and thawing hazards, before or during installation, and where the average frost depth is less than 18 inches, the freezing and thawing and absorption tests may be modified or waived.

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[2] Superintendent of Documents, U. S. Government Printing Office Washington, D. C. 20402

Concrete Tile - The use of concrete tile under acid and sulfate conditions shall be in accord with the following guides:

ACID SOILS

Class of tile	Lower Permissible Limits of pH Values[3] Organic and Sandy Soils	Lower Permissible Limits of pH Values[3] Medium and Heavy-Textured Soils
ASTM C 412:		
Standard Quality	6.5	6.0
Extra Quality	6.0	5.5
Special Quality	5.5	5.0
ASTM C 14, C 118, C 444	5.5	5.0

[3]Figures given represent lowest readings of pH values for soil water or soil at tile depth.

SULFATE SOILS

Permissible Maximum Limit of Sulfates Singly or in Combination[4] (Parts per Million)	Type of Tile and Cement (Minimums)	
7,000	Tile:	ASTM C 412 Special Quality, C 14, C 118, C 444
	Cement:	ASTM C 150 Type V
3,000	Tile:	ASTM C 412 Extra Quality, C 14 C 118, C 444
	Cement:	ASTM C 150 Type II or V
1,000	Tile:	ASTM C 412 Standard Quality C 14, C 118, C 444
	Cement:	ASTM C 150 - Any Type

[4]Highest reading of sulfates for soil or soil water at tile depth.

Other Clay and Concrete Pipe - Bell and spigot, tongue and groove, and other pipe which meets the strength, absorption, and other requirements of clay or concrete tile as covered above, except for minor imperfections in the bell, the spigot tongue or the groove, and ordinarily classed by the industry as "seconds," may be used for drainage conduits provided the pipe is otherwise adequate for the job.

Foundation Requirements

Soft or yielding foundations shall be stabilized where required and lines protected from settlement by adding gravel or other material to the trench, placing the conduit on plank or other rigid supports, or using long sections of perforated or water-tight pipe.

Loading

The allowable loads on drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Filters and Filter Material

Suitable filters shall be used around drains where required by site conditions to prevent sediment accumulation in the conduit. The need for a filter shall be determined by the characteristics of the soil materials at drain depth and the velocity of flow in the conduit.

Not less than three inches of filter material shall be used for sand-gravel filters. A recommended method of installation is to place filter material to a depth of three inches under the drain, and cover the drain and filter with a sheet of plastic. The filter shall be designed to prevent the material in which the installation is made from entering the drain. Not more than ten percent of the filter shall pass the No. 60 sieve.

Where fiber-glass filter material is used, it shall be manufactured from borosilicate type glass and the manufacturer of the material shall certify that it is suitable for underground use. The fibers shall be of variable size, with some larger fibers intertwined in the mat in a random manner. The material shall cover all open joints and perforations.

Envelopes and Envelope Material

Envelopes shall be used around drains where required for proper bedding of the conduit, or where necessary to improve the characteristics of flow of groundwater into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit.

Placement and Bedding
All drains, both flexible, as plastic tubing, and non-flexible, as clay and concrete tile, shall be laid to line and grade and covered with approved blinding, envelope, or filter material to a depth of not less than 3 inches over the top of the drain. Either of the two methods below may be used.

1. Except as provided in Method 2 below, the bottom of the excavated trench shall be shaped or grooved. Flexible type drains, when placed, shall be embedded in undisturbed soil for approximately 60 degrees of their circumference. After placement of all types of drains, friable material taken from the trench spoil or cut from the trench side walls shall be placed around the drain in such a manner that it will completely surround and support the drain and fill the trench to a depth of 3 inches over the top of the drain. To be suitable, materials surrounding the drain must contain no hard clods, rocks, or fine materials which would cause a silting hazard in the drain.

2. When special shaping or grooving of the trench bottom is not provided to embed the drain when placed, the drain shall be laid directly upon the flat, unshaped bottom and both sides covered with an envelope material of sufficient quantity to fill the trench to a depth of 3 inches over the top of the drain. Envelope material shall consist of sand-gravel material, all of which shall pass a 1-1/2-inch sieve, 90 to 100 percent shall pass a 3/4-inch sieve, and not more than 10 percent shall pass a No. 60 sieve.

The gap between tile or other drain pipe joints shall not exceed 1/4 inch for mineral soils or 1/2 inch for organic soils. Openings wider than these, occurring on the outer side of a curve in a tile line or due to tile irregularity, shall be permitted if they are covered with broken tile, fiber glass, or other suitable material.

Auxiliary Structures and Drain Protection
The outlet shall be protected against erosion and undermining of the drain, against damaging periods of submergence, and against entry of rodents or other animals into the drain. A continuous section of pipe without open joints or perforations shall be used at the outlet end of the line and shall outlet above the normal elevation of low flow in the outlet ditch.

The pipe and its installation shall conform to the following requirements:

1. Where there is a hazard of burning to vegetation on the outlet ditch bank, the material from which the outlet pipe is fabricated shall be fire resistant. Where the hazard of burning is high, the outlet pipe shall be fireproof.

2. Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend beyond the toe of the ditch side slope or the side slope shall be protected from erosion. The minimum length of pipe shall be eight feet.

3. Where ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered portion of the pipe will be protected from the current in the ditch.

4. Headwalls which are used for drain outlets shall be adequate in strength and design to avoid washouts and other failures.

Watertight conduit strong enough to withstand the loads upon it shall be used where subsurface drains cross under irrigation canals or other ditches. Conduits under roadways shall be designed to withstand the expected loads. Shallow drains through depressional areas and near outlets shall be protected against hazards of farm and other equipment, and freezing and thawing.

Junction boxes shall be used where more than two main lines join.

Where surface water is to be admitted to drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Drain lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Auxiliary surface waterways shall be used where feasible.

The upper end of each drain line shall be capped with concrete or other durable material unless connected to a structure.

Plans and Specifications

Plans and specifications for installation of drains shall be in keeping with this standard and shall describe the requirements for installation of the practice to achieve its intended purpose. See page S-606-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

MATERIALS SPECIFICATIONS

All materials currently acceptable for installation as Drains and the specifications for use in determination of the physical requirements and testing of all of the approved materials, with the exception of corrugated plastic drainage tubing, are listed in the table of materials on pages 606-4&5.

Specifications for corrugated plastic drainage tubing are as follows:

Specification for Corrugated Polyethylene Drainage Tubing

1. PURPOSE

1.1 The purpose of this standard is to establish standard material, workmanship, dimensions, strength and other significant quality requirements for corrugated polyethylene drainage tubing to be used for subsurface agricultural drainage.

2. SCOPE

2.1 This standard covers requirements and methods of test for materials, dimensions, workmanship, crushing strength and water inlet areas for corrugated P.E. drainage tubing. A form of marking and practices for indicating compliance with this standard are also given.

3. TERMINOLOGY

3.1 The plastics terminology used in this standard is in accordance with the definitions given in Tentative Nomenclature Relating to Plastics (ASTM Designation: D 883), unless otherwise noted.

4. REQUIREMENTS

4.1 Materials Requirements

4.1.1 Raw Material--Compounds used in the manufacture of corrugated P.E. drainage tubing shall conform with the requirements of Type III, with a maximum density of 0.960, Class "C", Category 3, Grade P 33 polyethylene, as specified in ASTM D 1248.

4.1.2 Rework Material--Clean rework material, generated from the manufacturer's own production, may be used by the same

manufacturer provided that the tubing produced is equal in quality to tubing extruded from virgin material.

5. TUBING REQUIREMENTS

5.1 Workmanship--The tubing shall be homogeneous throughout and free from foreign inclusions or visible defects. The tubing shall be uniform as commercially practicable in color, opacity, density, and other physical properties.

5.2 Dimensions

5.2.1 Inside Diameter--Corrugated P.E. drainage tubing shall have an inside diameter of not less than 4 inches.

5.2.2 Lengths--Corrugated P.E. drainage tubing shall be provided in lengths of not less than 30 feet unless otherwise specified.

5.3 Crushing Strength--Corrugated P.E. drainage tubing shall have a minimum crushing strength of 23.5 pounds per square inch when tested in accordance with paragraph 7.3.

5.4 Water Inlet Area--Corrugated P.E. drainage tubing shall have a water inlet area of at least 0.75 square inches per foot, provided by perforations spaced uniformly along the long axis of the tubing. The perforations shall have a width or diameter of between 1/32 and 1/8 inch unless a different size is specified for a particular job. All measurements are to be made in accordance with paragraph 7.6.

6. SAMPLING AND RETEST

6.1 Sampling--A sample of tubing sufficient to determine conformance with this standard shall be taken at random from each lot or shipment.

6.2 Retest--If the results of any test do not conform to the requirements prescribed in this standard, the test shall be repeated on two additional samples from the same lot or shipment, each of which shall conform to the requirements specified. If either of these two additional samples fail, the tubing does not comply with this standard.

7. METHODS OF TESTS

7.1 Conditioning Test Specimens--The specimen shall be conditioned prior to test at 23 ± 2° C. (73.4 ± 3.6° F.) and 50 ± 5 percent relative humidity for not less than 48 hours in accordance with Procedure A in Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing (ASTM Designation: D 618) for those tests where conditioning is required and in all cases of disagreement.

7.2 Test Conditions--Tests shall be conducted in a laboratory atmosphere of 23 ± 2° C. (73.4 ± 3.6° F.) and 50 ± 5 percent relative humidity, unless otherwise specified.

7.3 Crushing Strength--Sand Box Method

7.3.1 Construction of apparatus--the bottom of the box shall be square with inside dimensions three times the inside diameter of the tubing (3D), and the box shall be not less than 3.75 D inches high by inside measurement. Two sides should be constructed of 3/4" thick plexiglass so the test specimen may be visually observed during the test. Two sides of the box should be sturdily constructed of 1/4" steel plate and joined securely to the plexiglass sides. Other materials may be used so long as the box is capable of withstanding a minimum of 62.5 pounds per square inch internal pressure. The top of the box shall be open except for the bearing plate.

The top bearing plate shall be 2 D inches square and fastened to the ram of the testing machine securely and parallel to the base of the box. It should be of 3/4" thick steel or other material capable of withstanding 4000 pounds force with a minimum of deflection.

7.3.2 Testing medium--The test specimen shall be surrounded by dry Ottawa sand.

7.3.3 Preparation of test specimen--The specimen shall be conditioned in accordance with paragraph 7.1. The specimen shall be exactly 3 D inches in length and shall be squarely cut at the ends. The specimen shall contain water inlet slots in accordance with paragraph 5.4. It will be permissible to use narrow strips of masking tape placed carefully over the slots to prevent the sand from filling the inside of the specimen. These strips of masking tape should be as small as possible and not placed in such a manner as to affect the strength of the specimen.

7.3.4 Placement of test specimen in sand box--A layer of sand 3 inches deep shall first be placed in the box and leveled carefully to a uniform depth. The sand shall be poured from a suitable container into the box and not packed or compressed into place. The test specimen shall then be placed on the sand with its open ends against the plexiglass sides of the box and centered carefully in the box. Dry Ottawa sand shall then be poured into the box and leveled to a depth of 1.5 D inches over the specimen.

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7.3.5 Application of load--The load may be applied to the top bearing plate with any mechanically driven, hydraulically or hand-powered device provided it meets the following requirements: It shall be substantially built and rigid throughout so that distribution of the load to the specimen shall not be affected appreciably by the deflection or deformation of the loading device. The device shall be so constructed that a uniform loading rate not to exceed 1/10 of an inch per minute can be maintained throughout the test. The loading device shall provide means for measuring the load continuously throughout the test to an accuracy of ± 2 percent of indicated reading. The top bearing plate must be centered accurately in the box and the loading device must be accurately centered on the top bearing plate.

7.3.6 Conduct of the test--The load shall be applied in accordance with paragraph 7.3.5. The values of the load as well as the test specimen shall be visually observed and the value of the load shall be recorded at failure of the test specimen. The value of failure shall be defined as the maximum loading value reached before a steady decline in loading occurs. At this point the loading may be stopped and the test concluded. The crushing strength of the tubing in pounds per square inch shall be tabulated as the pounds of force applied at failure divided by the area of the pressure plate in square inches.

7.4 Materials Tests--All materials tests shall be conducted in accordance with Tentative Specification for Polyethylene Molding and Extrusion Materials (ASTM Designation: D 1248).

7.5 Dimensions

7.5.1 Inside Diameter--The inside diameter of the tubing shall be measured with a tapered plug in accordance with Section 5 of Method of Determining Dimensions of Thermoplastic Pipe (ASTM Designation: D 2122).

7.5.2 Length--Tubing shall be measured with a steel tape accurate to ± 1/32 inch in 10 feet. All measurements shall be made on the tubing resting naturally on a relatively flat surface in a straight line with no external forces of tension or compression exerted on the tubing.

7.6 Water Inlet Area--Dimensions of water inlet area shall be measured on a straight specimen with no external forces applied. All measurements shall be made with instruments accurate to 0.001 inch.

8. MARKING AND DECLARATION OF COMPLIANCE

8.1 Marking--Corrugated polyethylene drainage tubing complying with this specification shall be marked with the manufacturer's identification symbol regularly at no more than 10 foot intervals.

8.2 Declaration of Compliance--The following statement shall appear on invoices, sales literature and quotations concerning tubing complying with this specification: "This corrugated polyethylene tubing complies with all applicable requirements of Specification for Corrugated Polyethylene Drainage Tubing contained in Soil Conservation Service Engineering Practice Standard for Drain, Code. 606."

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DRAIN SYSTEM STRUCTURE

Definition

An auxiliary structure installed in an existing or new subsurface drainage system.

Scope

This standard covers pipe drops, headwalls, junction boxes, surface water inlets, manholes, catch basins, sand traps, observation wells, relief wells, vents and other special purpose structures which are an integral part of the subsurface drainage system.

Purpose

The principal purposes are to protect the ends of lines, to control grade and velocity, regulate flow, join lines, collect sediment and debris, provide access for inspection, prevent erosion, regulate water table levels, relieve hydrostatic pressures, and permit the escape or entrance of air.

Conditions Where Practice Applies

This standard applies to all subsurface drainage systems (new or old) where such structures are needed to provide adequate water control.

Design Criteria

Structure Capacity

Structures installed in drain lines must not unduly impede the flow of water in the system. They shall have a capacity no less than that of the line or lines feeding into or through them.

Where the drain system will carry surface waterflow, surface water inlets shall have a capacity no less than that required to provide the maximum design flow in the drain line or lines.

The capacity of a relief well system shall be based on the flow from the aquifer, the well spacing, and other site conditions and shall be adequate to lower the artesian waterhead to the desired level.

Size of Structures

Junction boxes, manholes, catch basins, and sand traps shall be accessible for maintenance. A clear opening of not less than 2 feet shall be provided in either circular or rectangular structures.

The size of relief wells is generally established by available equipment rather than hydraulic considerations. Such wells shall not be less than 6 inches in diameter.

Velocities in Structures

The drain system shall be protected against velocities exceeding those in the table at the top of page 606-4 of the standard for Drain, and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed-joint pipe shall be used in drain lines adjoining the structure where excessive velocities will occur.

Screens and Trash Racks

Surface water inlet structures shall be equipped with screens, trash racks, or gratings to exclude debris.

Junction Boxes

Junction boxes shall be installed where more than two main drains join, or where two main drains join at different elevations.

Plans and Specifications

Plans and specifications for installation of Drain System Structures shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DRAINAGE FIELD DITCH

Definition

A graded ditch for collecting excess water within a field. This does not include Drainage Main or Lateral, or Grassed Waterway or Outlet.

Purpose

Drainage field ditches are installed to:

1. Drain surface depressions.

2. Collect or intercept excess surface water such as sheet flow from natural and graded land surfaces or channel flow from furrows for removal to an outlet.

3. Collect or intercept excess subsurface water for removal to an outlet.

Conditions Where Practice Applies

Applicable sites are flat or nearly flat lands that:

1. Have soils of low permeability or shallowness over barriers, such as rock or clay, which hold or prevent ready percolation of water to a deep stratum.

2. Have surface depressions or barriers which trap rainfall.

3. Have insufficient land slope for ready movement of runoff across the surface.

4. Receive excess runoff or seepage from uplands.

5. Require removal of excess irrigation water.

6. Require control of the groundwater table.

7. Have adequate outlets available for disposal of drainage water by gravity flow or pumping.

Design Criteria

Drainage field ditches shall be planned as integral parts of a drainage system for the field served and shall collect, intercept, and remove water to an outlet with continuity and without ponding.

Investigations

An adequate investigation shall be made of all sites. Soils to be drained shall be suitable for agricultural use.

Location

Ditches shall be established, insofar as topography and property boundaries permit, in straight or nearly straight courses. Random alignment may be used to follow depressions and isolated wet areas of irregular or undulating topography. Excessive cuts, and the creation of small irregular fields should be avoided.

On extensive areas of uniform topography, collection or interception ditches shall be installed as required for effective drainage.

Design

The size, depth, side slopes, and cross section area shall:

1. Be adequate to provide the required drainage for the site.
2. Permit free entry of water from adjacent land surfaces without causing excessive erosion.
3. Provide effective disposal or reuse of excess irrigation water (where applicable).
4. Conduct flow without excessive erosion.
5. Provide stable side slopes based on soil characteristics.
6. Permit crossing by farm equipment where feasible.
7. Permit construction and maintenance with available equipment.

Plans and Specifications

Plans and specifications for construction of Drainage Field Ditches shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DRAINAGE LAND GRADING

Definition

Reshaping the surface of land to be drained by grading to planned grades. This practice requires a detailed engineering survey and layout. This is in contrast with Land Smoothing where detailed engineering survey and layout are not performed. This does not include Irrigation Land Leveling or Recreation Land Grading and Shaping.

Purpose

The purposes of the practice include one or more of the following: improve surface drainage, provide more effective utilization of rainfall, improve equipment operation and efficiency, facilitate the installation of a more workable drainage system, and reduce the incidence of mosquito infestation.

Conditions Where Practice Applies

This practice applies on land where depressions, mounds, old terraces, turn rows and other surface irregularities prevent adequate surface drainage and where precision grading is practical. All land to be graded shall be suitable for the planned use.

Soils shall be of sufficient depth and suitable texture so that after the needed grading work is done an adequate root zone remains which will permit planned land use with the application of proper conservation measures, soil amendments and fertilizer as needed.

Design Criteria

The design and installation shall be based on adequate surveys and investigations.

Designed slope and dimension limitations shall be the limits which have been found to be suitable for the particular site conditions, conservation system or land use to be applied. Where other conservation practices are needed to accomplish the stated purpose they shall be included in the plans for improvement.

Plans and Specifications

Plans and specifications for application of Drainage Land Grading shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve the intended purpose. See page S-462-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

DRAINAGE MAIN OR LATERAL

Definition

An open drainage ditch constructed to a designed size and grade. Does not include Drainage Field Ditch.

Scope

This standard covers ditches for disposal of surface and subsurface drainage water primarily collected by drainage field ditches and subsurface drains. It also covers the minimum drainage requirements for multiple-purpose channels which provide drainage outlets for agricultural lands, but the design criteria for such channels shall be in accord with the standard for Code 582, Open Channel.

Purpose

The purpose of mains and laterals is to dispose of excess surface or subsurface water, intercept groundwater, or to control groundwater levels; to provide for leaching of saline or alkali soils; or a combination of these objectives.

Conditions Where Practice Applies

All lands to be drained shall be suitable for agricultural use within their land capabilities after installation of required drainage and other conservation practices.

An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall provide for the quantity and quality of water to be disposed of, with consideration of possible damages above or below the point of discharge that might involve legal actions.

Design Criteria

The design and installation shall be based on adequate surveys and investigations.

Drainage Requirements

Mains and laterals shall be located and designed to serve as integral parts of a surface or subsurface drainage system that meets the conservation and land use needs. The degree of drainage required by the crops shall be determined and expressed in terms of drainage coefficients or depth and spacing of drains.

Required Capacity of Mains and Laterals
The ditch capacity shall provide for the removal of excess water based on climatic and soil conditions and the needs of crops. The required capacity shall be obtained by determining the watershed area; the required topographic, soil, and land use information; and use of the appropriate drainage coefficient curves.

The required capacity of open ditches for subsurface drainage in Western irrigated areas shall be determined by evaluating site conditions, including irrigation water deliveries, irrigation canal or ditch losses, soil stratification and permeability, deep percolation losses, field irrigation losses, and quantity of surface water to be carried by the drainage ditch.

Hydraulic Grade Line
The hydraulic grade line for drainage ditch design shall be determined from control points including elevations of significant low areas served by the ditch and hydraulic grade lines of any tributary ditches and the outlet. Where control point elevations are estimated rather than computed from survey data, the hydraulic grade line shall be no less than:

1. One foot below fields which will receive normal drainage from ditches draining more than 1 square mile.

2. 0.5 foot for ditches draining 40 to 640 acres.

3. 0.3 foot for ditches draining less than 40 acres.

For lands to be used only for the more water-tolerant crops such as trees and grasses, these requirements may be modified and the hydraulic grade line set at ground level. These provisions do not apply to channels where flow is contained by dikes.

The effects of hydraulic losses caused by culverts, bridges, or other obstructions in the channel section shall be considered.

Depth Requirements
Drainage ditches shall be designed with enough depth to allow for normal siltation. Increases in design depth and capacities to provide adequate subsurface drainage or for normal flow shall be made where needed, based on an evaluation of site conditions. Ditches that serve as outlets for subsurface drains shall be designed for a normal water surface at or below the invert of the outlet end of the drain. The clearance between a drain invert and the ditch bottom shall be at least 1 foot for ditches which fill with sediment at a normal rate, except where lower values are specified for a job because of unusual site conditions. The normal water surface is defined as the elevation of the usual low flow during the growing season.

Cross Section

The design ditch cross section shall be set below the design hydraulic grade line and shall meet the combined requirements of capacity, limiting velocity, depth, side slopes, bottom width, and, if needed, allowances for initial sedimentation. Side slopes shall be stable, meet maintenance requirements, and be designed based on site conditions.

Velocity

The maximum permissible design velocity shall be based on site conditions and shall be such as to result in stability of ditch bottoms and side slopes. A desirable minimum velocity is 1.5 feet per second. On flat grades a channel cross section should be selected, in accord with depth and maintenance requirements, which will result in the desirable minimum velocity if possible.

Channel velocities for newly constructed channels with drainage areas in excess of one square mile shall be within the requirements of Code 582 for channel stability.

Value of "n" in Manning's Formula for Capacity Design

Manning's formula shall be used for determining the design velocity and the value of "n" shall be based on alignment, probable vegetative growth expected with normal maintenance, other roughness factors, and the hydraulic radius. Unless special site studies are available to justify other values, the following values of "n" based on the hydraulic radius of the channel, and assuming an aged channel with good maintenance and good alignment shall be used in the solution of the Manning formula for Mains and Laterals when determining the design for required capacity.

Hydraulic Radius	"n"
less than 2.5	0.040 - 0.045
2.5 to 4.0	.035 - .040
4.1 to 5.0	.030 - .035
more than 5.0	.025 - .030

Berms and Spoil Banks

Adequate berms shall be provided and shaped as required to provide access for maintenance equipment, to eliminate the need for moving spoil banks in future operations, to provide for work areas and facilitate spoil-bank spreading, to prevent excavated material from washing or rolling back into ditches, and to lessen sloughing of ditchbanks caused by heavy loads too near the edge of the ditchbanks. The following minimum berm widths shall be provided except in those cases where spoil is spread in accord with the Engineering Standard for Spoilbank Spreading:

Ditch Depths Feet	Minimum Berm Width Feet
2 - 6	8
6 - 8	10
Over 8	15

Where spoil material is to be placed in banks along the ditch rather than spread over adjacent fields, the spoil banks shall have stable side slopes. Provision must be made to channel water through the spoil and into the ditch without causing serious erosion.

Travelways for Maintenance
All drainage mains and laterals with drainage areas in excess of one square mile shall be provided with travelways for maintenance as specified in standard for Open Channel, Code 582.

Related Structures and Ditch Protection
Mains and laterals shall be protected against erosion by chutes, drop structures, pipe drops, other suitable structures or grassed waterway, or specially graded channel entrances where surface water or shallow ditches enter deeper ditches.

Grade control structures, bank protection, or other suitable measures shall be used where necessary to reduce velocities and control erosion.

Culverts and bridges shall have enough hydraulic capacity and depth for drainage needs and to minimize obstruction to flow.

Capacities of pipe or drop structures ordinarily shall be determined by use of the applicable drainage coefficients with the "island" type of construction used to protect the structure from washout.

Each structure for an open ditch system shall be designed in accordance with Soil Conservation Service Standards for the kind of structure and type of construction involved.

Plans and Specifications

Plans and specifications for the construction of Drainage Mains or Laterals shall be in keeping with this standard and shall describe the requirements for construction of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

FLOODWATER DIVERSION

Definition

A graded channel with a supporting embankment or dike on the lower side constructed on lowland subject to flood damage. Does not include Floodway or Diversion.

Purpose

This practice is to divert floodwater from lowlands by the construction of a graded channel on the lowlands.

Conditions Where Practice Applies

This practice is applicable where:

1. Floodwater which originates outside the lowland area to be protected is causing damage to agricultural land, crops, or improvements, or is expected to cause damage to improvements to be made in the area.

2. An adequate outlet for the design flow is available, either by gravity flow or by pumping. The outlet shall be suitable for the quality and quantity of water and sediment to be disposed of, with consideration of possible damages above or below the point of discharge that might involve legal actions under state law. The outlet may be a Floodway (404), a natural channel, river, lake, bay, or tidal estuary.

3. Lands to be protected are suitable for agricultural use within their capabilities after installation of required conservation practices.

4. All state laws and property rights regarding diversion or discharge of floodwaters are complied with.

This practice does not include diversions constructed on uplands which may provide benefits to bottom lands; or dams constructed to divert floodwaters into a waterspreading system, irrigation canal, or storage facility for beneficial use. A Diversion Dam (348) may discharge into a Floodwater Diversion.

Design Criteria

Location
The floodwater diversion shall be located to protect the maximum area of lowland, consistent with economic limitations, topographic requirements, and the desired slope of the hydraulic gradeline.

In selecting the location for Floodwater Diversions, consideration shall be given to the preservation of existing fish and wildlife habitat, trees of significant value for wildlife food, dens or shelter and trees of significant aesthetic value. Where a Floodwater Diversion will adversely affect a fish or wildlife habitat, mitigation measures acceptable to sponsors and concerned federal and state agencies shall be included in the plans.

Capacity
Floodwater diversions which are to protect agricultural land shall have the capacity to carry the peak runoff to be expected from a 10-year frequency storm. Where farmsteads, public roads, or other improvements are within the area to be protected, the design capacity shall be consistent with the hazard involved but shall not be less than the peak flow from a 25-year frequency storm.

Hydraulic Gradeline
The hydraulic gradeline of the floodwater diversion shall tie in to the elevation of water in the outlet expected for the frequency storm selected for design, and shall be established with due regard for damages which may occur on the opposite side of the floodwater diversion from the supporting embankment. It shall have a slope in the direction of flow which will result in a velocity that will not cause excessive erosion or sedimentation.

Cross Section
The design cross section shall be set below the design hydraulic gradeline and shall include the total cross-sectional area bounded by the embankment, the berm between embankment and channel, the channel, and the flow area on the opposite side of the channel from the embankment, but shall not include areas where the depth of flow is less than 2 feet below the hydraulic gradeline.

This cross-sectional area shall be adequate for the design capacity based on application of Manning's formula. The roughness coefficient used in design shall be selected according to the conditions expected after aging and the establishment of normal vegetation.

Velocity
Where site conditions indicate probable erosion due to a higher velocity resulting from a lower roughness coefficient immediately after construction and prior to establishment of vegetation, such lower value of roughness coefficient shall be estimated. The

resultant velocities shall be considered in designing the channel and planning protective measures. Criteria in the standard for practice Code 582 regarding channel stability, velocity and roughness coefficient shall be followed.

The maximum permissible design velocity shall be based on site conditions and determined by procedures described in SCS Engineering Division Technical Release 25, Planning and Design of Open Channels. A desirable minimum velocity is 1.5 ft. per sec. On flat grades where the design velocity is below this value, the cross section shall be adjusted to obtain the most efficient section that depth and maintenance methods permit.

Berm and Embankment

The minimum berm width between channel and embankment shall be based on depth of channel in accordance with the following:

Depth of Channel	Minimum Berm
feet	feet
2 - 4	4
4 - 6	6
6 - 8	10
over 8	15

Wider berms than the above should be used where site conditions permit.

The embankment may be constructed from the channel excavation or from suitable borrow.

The design height of the embankment shall be the design water depth plus a freeboard of at least 2 feet. The constructed height shall be the design height plus an allowance for settlement based on consideration of soil material and the anticipated compaction during construction but such allowance shall be no less than 5 percent of the design height.

The minimum requirements for the cross section of the embankment where fill is compacted by hauling or special equipment shall be as follows:

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Compacted Fills

Design Water Height	Minimum Top Width	Steepest Side Slope
feet	feet	
0 - 6	6	1-1/2:1
6 - 12	8	2:1

Where soils or water conditions make it impractical to compact the embankment with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated within the fill as follows:

Dumped Fills

Design Water Height	Minimum Top Width	Steepest Side Slope
feet	feet	
0 - 6	6	2:1
6 - 12	8	2-1/2:1

Side slopes of 3:1 on water side and 2:1 on land side may be used instead of 2-1/2:1 for both slopes.

Vegetative Cover
An adequate protective cover of grasses shall be established on the embankment where, in the judgment of the responsible technician, this is necessary to protect against erosion by flood flows, wave action, or from rainfall and runoff on the embankment. Seedbed preparation, seeding, sprigging, or sodding, fertilizing, mulching, and fencing shall comply with applicable technical guides.

Maintenance Access
Maintenance access shall be provided as specified in the standard for practice Code 582.

Plans and Specifications

Plans and specifications for construction of Floodwater Diversions shall be in keeping with this standard and shall describe the requirements for construction to achieve the intended purpose. See page S-400-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

FLOODWATER RETARDING STRUCTURE

Definition

A single-purpose structure providing for temporary storage of floodwater and for its controlled release.

Scope

This standard applies to class (a) structures where the product of the storage (in acre-feet at the elevation of the crest of the emergency spillway) and the height of the dam (in feet as measured from the lowest point in the original cross section on the centerline to the crest of the emergency spillway) is less than 3000. A class (a) structure is defined as a structure located in rural or agricultural areas where damage due to failure is limited to farm buildings, agricultural land, or township or county roads.

Purpose

Floodwater retarding structures are installed to reduce flood damages downstream by controlling the release rate from flood flows of predetermined frequencies. They may also permit the use of more economical channel improvements or stabilizing structures in the channel downstream, and reduce environmental hazards and pollution.

Conditions Where Practice Applies

This practice applies only to sites meeting all of the following conditions:

1. The construction of the structure is permitted by applicable State statutes and regulations.

2. Topographic, geologic, and soils conditions at the proposed site are satisfactory for the development of a feasible dam and reservoir.

3. The sediment yield at the site is not excessive.

Special attention will be given to maintaining habitat for fish and wildlife where applicable.

Design Criteria

The following design criteria shall be considered to be the minimum for structures in the size groups indicated. More conservative design criteria should be used when the structures approach the upper limits of size or storage-height product.

Important structures shall meet the requirements established in Engineering Memorandum 27.

Structures having a height as measured from the lowest point in the original cross section on the centerline to the crest of the emergency spillway greater than 20 feet shall meet the requirements established in Engineering Memorandum 27 for all elements that are not specially provided for below.

Structures having a height (as measured above) of 20 feet or less shall meet the requirements established in the Engineering Standard and Specifications Guide for Pond (378) for all elements that are not specially provided for below.

Special Provisions

These provisions modify the criteria given in Engineering Memorandum 27 and in the Engineering Standard and Specifications Guide for Pond (378) with respect to the following elements:

Principal Spillway - The capacity of the principal spillway should be adequate to discharge, in 10 days or less, the floodwater storage needed to provide the desired level of protection to the downstream benefited area. Storage provided primarily for the purpose of reducing the frequency of use of the emergency spillway need not be included in this 10-day drawdown limitation. The determination of capacity must be based on a consideration of the benefits that accrue to the reduction in the discharge rate, damages that may result from prolonged storage in the retarding pool, damages that may result from prolonged outflow, and limitations in water rights or other legal requirements. The discharge through gated outlets shall not be considered in determining the emptying time of the retarding pool.

Except as modified by the Watershed Protection Handbook for structures built under the Flood Prevention and Watershed Protection programs, the elevation of the crest of the lowest stage of the principal spillway shall be the elevation of the sediment pool. For dry dams, the riser shall be designed to permit design discharge at the sediment pool elevation with provisions for discharging water at lower elevations to satisfy the functional requirements of the structure.

All component parts of the principal spillway except attached gates and trash racks shall have an expected service life equal to or greater than the design life of the structure. Principal spillways in structures having a design life of 50 years or greater shall meet the requirements with respect to materials established in the Principal Spillway section of Engineering Memorandum 27.

The minimum diameter of the conduit used as a principal spillway shall be 10 inches.

Anti-seep collars shall be provided in all cases. Collars and their connection to the pipe shall be watertight. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe.

When cantilever outlets are used, bents or piers may not be needed to support the pipe when the pipe diameter is 18 inches or less. The need for structural support in these instances shall be determined from an evaluation of site conditions.

Sediment Storage Requirements - The storage volume to be provided shall not be less than the expected sediment accumulation during a period equal to the design life. Principles and criteria specified in Engineering Memorandum 27 shall be followed in determining this volume.

Floodwater Storage Requirements - The retarding storage requirements shall be such as to contain the runoff expected to occur at a frequency consistent with the level of protection to be provided to the downstream benefitted area, with proper allowance made for discharge through the principal spillway. The retarding storage capacity shall be sufficient to limit the use of the emergency spillway to a permissible frequency and duration based upon a consideration of the erosion resistance of the spillway material and the vegetative protection to be provided.

Emergency Spillways - An emergency spillway must be provided for each structure, unless the principal spillway is large enough and of a design which will pass the routed design runoff and the trash that comes to it. Earth spillways shall have a minimum bottom width of 10 feet. The crest of the emergency spillway shall be at least 2 feet below the top of the settled embankment. When the height of the dam (as previously defined) is 20 feet or less, the minimum design capacity of a natural or constructed emergency spillway shall be that required to convey the routed runoff from a 25-year frequency storm, or a storm with a frequency equal to the design life of the structure, whichever is greater.

When the height of the dam (as previously defined) is over 20 feet, the minimum design capacity of the emergency spillway shall be that required to convey the routed runoff from a 50-year frequency storm, or a storm with a frequency equal to the design life of the structure, whichever is greater.

The storm runoff shall be routed through the reservoir starting with the water surface at the elevation of the crest of the principal spillway or at the water surface elevation after 10 days of drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the emergency spillway or from the elevation that would be attained had the entire design storm runoff been impounded, whichever is lower.

All spillways shall be designed for safe velocities through the control section and a reasonable distance below.

Freeboard - The minimum elevation at the top of the settled embankment shall be at least 1 foot above the water surface in the reservoir with the emergency spillway flowing at design depth and 2 feet above the crest of the emergency spillway.

Plans and Specifications

Plans and specifications for installation of Floodwater Retarding Structures shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-402-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

FLOODWAY

Definition

A channel, usually bounded by dikes, used to carry flood flows.

Purpose

Floodways are used to carry floodwater from a side drainage across a flood plain into the channel of a main stream. They are also used along the course of a main stream where, by means of dikes, a portion of the flood plain is used to carry floodwater and the balance of the flood plain is protected.

Conditions Where Practice Applies

Floodways are applicable to overflow areas of streams or rivers where existing channels are inadequate to carry the floodwaters without flooding and damaging property, and the design storm discharge can be confined between dikes or a combination of channel and dikes without causing excessive erosion. A floodway is applicable to sites where the storm runoff from side tributaries which will be ponded outside the floodway will not cause damages in excess of the benefits less the cost of the project.

This practice does not include Floodwater Diversions (400) which divert water from lowlands. A floodwater diversion may empty into a floodway. This practice does not include channel improvement where the spoil is set back from the excavated areas and where no provision is made to confine the floodwater to the channel side of the spoil.

An outlet for the floodway must be available which will provide for the discharge of the quantity of water for which the floodway is to be designed without creating stage increases in the outlet which could result in damages above or below the point of discharge that might involve legal actions under state law.

Classification

Since a large percentage of floodways include dikes as a major feature of the floodway, the same classification used for dikes will be used for floodways. The classes are defined in the standard for Dike (356).

CLASS I FLOODWAYS

Class I Floodways are those which:

1. Include Class I Dikes as a feature of the floodway, or

2. Are constructed to protect areas where either of the following conditions apply:

    a. There is a possibility of loss of life should failure occur.

    b. High value land or improvements are to be protected.

CLASS II FLOODWAYS

Class II Floodways are those which:

1. Include Class II Dikes as a feature of the floodway, or

2. Are constructed to protect agricultural lands of medium to high capability with improvements generally limited to farmsteads and allied farm facilities.

CLASS III FLOODWAYS

Class III Floodways are those which:

1. Include Class III Dikes as a feature of the floodway, or

2. Are constructed to protect agricultural lands of relatively low capability or improvements of low value.

Design Criteria

The design and installation of the floodway and each of its features shall be based on engineering surveys and investigations which shall be made as provided in applicable sections of the SCS National Engineering Handbook and SCS Engineering Division Technical Release No. 25, "Planning and Design of Open Channels." Rates of flow resulting from runoff from the storm against which protection is to be provided and the design for stability of the channel included in the floodway shall be determined from and based on these investigations. Criteria for channel stability, velocity and coefficient of roughness contained in the standard for practice Code 582 shall be followed.

The proportioning of the width and depth of flow in the floodway shall be based on consideration of the area to be occupied by the floodway with respect to the area to be protected, requirements for entrance of side drainage into the floodway, stage of water in the

outlet for the design storm, velocities in the floodway at design flow and requirements for stability of the channel and dikes, and the effect on the water surface profile upstream from the floodway.

When designing floodways, the effect of future upstream floodway construction which will increase the peak rate of flow, should be considered. Provisions to allow future enlargement of the floodway to take care of this increase may be warranted.

The location and design of floodways shall give careful consideration to the preservation of valuable fish and wildlife habitat and trees which are of significant value for wildlife food or shelter or for aesthetic purposes.

Where floodway construction will adversely affect a significant fish or wildlife habitat, mitigation measures, acceptable to sponsors and concerned federal and state agencies, shall be included in the project.

From an economic standpoint, the best design for the floodway, including channel improvement and the correct proportioning of the width of the floodway and the height of dikes is that which results in a minimum sum for the cost of the dikes, channel improvements, and the value of the unprotected land in the floodway. The value of the unprotected land for this analysis would be the difference in its value if it could be protected and its value for floodway purposes.

Class I Floodways

Class I Floodways shall be designed to provide maximum feasible protection. Where urban protection is one of the primary objectives of a project or segment thereof, the project will be planned to keep water out of the main part of the urban area if the largest flood of record were repeated. Such protection should rarely be less than the 100-year frequency level.

Dikes used or constructed as a part of Class I Floodways shall meet SCS criteria established for Class I Dikes.

Class II Floodways

When dikes are included as a feature of Class II Floodways they shall meet the SCS Engineering Standard for Class II Dikes and the design criteria established thereby shall also apply to the floodway.

When dikes are not included in Class II Floodways, the floodway shall have the capacity to carry the peak runoff from a 10-year frequency storm as a minimum.

Class III Floodways

When dikes are included as a feature of Class III Floodways, they shall meet the SCS Engineering Standard for Class III Dikes and the design criteria established thereby shall also apply to the floodway.

When dikes are not included in Class III Floodways, the floodway shall have the capacity to carry the design flow selected on the basis of a study of site conditions.

Maintenance Access
Maintenance access as specified in the standard for practice Code 582 shall be provided.

Plans and Specifications

Plans and specifications for construction of Floodways shall be in keeping with this standard and shall describe the essential requirements for proper installation of each feature of the floodway to achieve the intended purpose. See page S-404-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

GRADE STABILIZATION STRUCTURE

Definition

A structure to stabilize the grade or to control head cutting in natural or artificial channels. (Does not include straight pipe overfall structures used in drainage and irrigation systems for structures for water control.)

Scope

This standard applies to all types of grade stabilization structures.

Purpose

Grade stabilization structures are installed to stabilize the grade in natural or artificial channels, prevent the formation or advance of gullies, and reduce environmental and pollution hazards.

Conditions Where Practice Applies

These structures apply where the concentration and flow velocity of water are such that structures are required to stabilize the grade in channels or to control gully erosion. Special attention will be given to maintaining or improving habitat for fish and wildlife, where applicable.

Design Criteria

Structures

Grade stabilization structures of materials such as concrete, rock, masonry, steel, aluminum and treated wood shall be designed in accordance with the principles outlined in Sections 5, 6, 11 and 14 of the National Engineering Handbook or approved State standards.

Embankment

Earthfill embankments shall be designed as follows:

1. Embankments for class (a) structures having a height of 20 feet or less as measured from the lowest point on the original centerline profile to the crest of the emergency spillway will meet the Engineering Standard and Specifications for Pond (378).

2. The design of embankments for all structures exceedings the limitations in 1 above either in dimension or hazard shall be based on State standards and criteria where the product of height times storage is less than 3,000 and on the requirements of Engineering Memorandum-27 when the product exceeds 3,000.

3. Simple structures with island type construction shall have fill sideslopes and top width that will provide a stable structure for local conditions.

Plans and Specifications

Plans and specifications for installation of Grade Stabilization Structures shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-410-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

GRASSED WATERWAY OR OUTLET

Definition

A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for the safe disposal of runoff from a field, diversion, terrace, or other structure.

Purpose

Grassed waterways or outlets are to provide for the disposal of excess surface water from terraces, diversions, or from natural concentrations without damage by erosion or flooding.

Conditions Where Practice Applies

These practices apply to all sites where added capacity or vegetative protection, or both, are required to control erosion resulting from concentrated runoff and where such control can be achieved by these practices alone, or in combination with others.

Design Criteria

Capacity

The minimum capacity shall be that required to confine the peak runoff expected from a storm of 10-year frequency except that on slopes of less than 1 percent, out-of-bank flow may be permitted where such flow will not cause erosion. The minimum in such cases shall be the capacity required to remove the water before crops are damaged.

Velocity

Design velocities shall not exceed those obtained by using the procedures, "n" values, and recommendations in SCS-TP-61, "Handbook of Channel Design for Soil and Water Conservation."

Width

The bottom width of trapezoidal waterways or outlets shall not exceed 100 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.

Depth

The minimum depth of a waterway or outlet receiving water from terraces, diversions, or other tributary channels shall be that depth required to keep the design water surface elevation in the waterway or outlet at, or below, the design water surface elevation in the

terrace, diversion, or other tributary channel at their junction when both are flowing at design depth.

Drainage

Tile or other suitable drainage measures shall be provided for in the design for sites having low flow, high water table, or seepage problems, except where water-tolerant vegetation such as Reed canary-grass can be used.

Plans and Specifications

Plans and specifications for installation of Grassed Waterways or Outlets shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

HEAVY USE AREA PROTECTION

Definition

Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures. (Does not include Critical Area Planting or Recreation Area Improvement.)

Purpose

This practice is used to stabilize an urban, recreation or essential facility areas subjected to sustained heavy use by people, animals or vehicles.

Conditions Where Practice Applies

On urban and recreation or other areas subjected to sustained heavy use that require special treatment to protect the area from erosion or other environmental deterioration.

Design Criteria

Drainage and Erosion Control
Provision shall be made for surface and subsurface drainage as needed and for disposal of runoff without erosion.

Base Course
All areas to be paved shall have a 6-inch base course of gravel, crushed stone, or other suitable material.

Areas subject to automotive traffic shall be designed for a wheel load of at least 4,000 pounds.

Surface Treatment
Asphalt - The thickness of the asphalt course, the kind and size of aggregate, type of proportioning of bituminous materials and the mixing and placing of these materials shall be in accord with good highway practice for the expected loading.

Concrete - The quality and thickness of concrete and the spacing and size of reinforcing steel shall be appropriate for the expected loading and in accord with sound engineering practice.

Gravel - Minimum thickness for gravel surface shall be 2 inches.

Other - Where other surfacing materials are used, such as cinders, tanbark, sawdust, etc., the minimum thickness shall be 2 inches.

Structures

All structures shall be designed in accordance with appropriate Soil Conservation Service standards and specifications or Engineering Handbook recommendations.

Sprays and Artificial Mulches

Sprays of asphalt, oil, plastic, manufactured mulches and similar materials will be installed in accordance with the manufacturers recommendations.

Vegetative Measures

Limeing, fertilizing, seeding and sodding will be in accord with the Vegetative Standards appropriate to the area.

Plans and Specifications

Plans and specifications for Heavy Use Area Protection shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

HILLSIDE DITCH

Definition

A channel with supporting ridge on the lower side constructed across the slope at definite vertical intervals and gradient, with or without vegetative barrier, to detain or control the flow of water to a protected outlet to check erosion on sloping land.

Scope

This standard covers the planning and design of hillside ditches on steep land and does not apply to diversions or terraces.

Purpose

Hillside ditches are constructed to divert runoff water to a protected outlet, and reduce slope lengths thus minimizing erosion and runoff.

Conditions Where Practice Applies

Hillside ditches are applicable to tropical lands determined to be suitable for cultivation and which has sufficient depth for construction.

Design Criteria

Location

Hillside ditch systems shall be designed to fit land conditions. They shall drain from the ridge to a stable outlet.

Outlets

Adequate outlets shall be provided prior to construction to dispose of discharge without creating an erosion hazard. Such outlets may be a natural or constructed waterway, a stable watercourse, or stable disposal areas such as well established pasture.

Length

Maximum length draining in one direction will be 400 feet. Length may be extended to 500 feet where necessary to reach a stable outlet.

Grade

The ditch grade may be either constant or variable but must not exceed 3 percent.

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Side Slopes
Side slopes shall be stable for the soil in which ditches are constructed.

Horizontal Spacing and Minimum Cross-Sectional Area
The maximum horizontal spacing and minimum cross-sectional area per 100 feet of ditch shall be as follows:

Average Slope Percent	Maximum Spacing Ft.	Minimum Cross Sectional Area Per 100 Ft. Length-Sq. Ft.
12 or less	40	.35
12 - 25	35	.3
25 - 40	25	.2

Plans and Specifications

Plans and specifications for installation of Hillside Ditches shall be in keeping with this standard and shall describe the requirements for application for the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

HOLDING PONDS AND TANKS

Definition

A fabricated structure or one made by constructing a pit, dam or embankment or combination thereof for temporary storage of animal or agricultural wastes, associated runoff and waste water. (Does not include disposal lagoon).

Scope

This standard establishes the minimum acceptable quality for design and construction of holding ponds and tanks as part of overall waste management systems in predominantly rural or agricultural areas. For holding ponds this standard is applicable to class (a) ponds with fill heights of 20 feet or less.

Purpose

Holding ponds and tanks are constructed to store liquid and solid manure and polluted runoff from feedlots, barnyards and similar areas until it can be safely utilized, evaporated or otherwise disposed of.

Conditions Where Practice Applies

General

This practice applies where there is need for facilities to temporarily store liquid and/or solid manure or other agricultural wastes, reduce sources of air and water pollution, minimize health hazards and improve the environment.

State and Local Laws

All state and local laws, water quality standards, rules and regulations governing the disposal of manure or other agricultural wastes must be strictly adhered to. The owner is responsible for securing any and all permits or approvals as required.

Design Criteria - Holding Ponds

Location

Locate holding ponds as near the source of polluted runoff as practicable giving due consideration to economics of gravity flow and plan of proposed disposal facilities. Locate where prevailing winds will minimize odor problems to neighbors and owner.

Holding ponds shall be located so that non-polluted runoff is excluded to the fullest extent possible.

Soil and Foundation
Locate on soils of low permeability or soils suitable for sealing to avoid pollution of ground water.

Settling Basin
To minimize frequent cleaning of solids from holding ponds it is desirable, where practical, to install low gradient inlet channels or debris basins to settle out most solids prior to entrance to the holding pond. The inlet channel or settling basin should have adequate capacity to store settled solids for a reasonable period of time based on the method of disposal, facilities available and expected volume.

Size of Holding Pond
Holding ponds shall have sufficient volume to temporarily store runoff to be expected from at least a 10-year, 24-hour storm. Additional storage, as appropriate, shall be provided where hazard of pollution potential dictates.

Disposal Facilities
Provisions for emptying the holding pond without polluting surface waters shall be provided to insure that sufficient capacity is available to receive the runoff from subsequent storms. Determination of emptying time shall be based on the chance of overflow from subsequent storm runoff and capacity of the disposal area. Emptying shall normally be accomplished by evaporation or land application through pump or gravity flow irrigation systems. Excess infiltration such as to pollute ground water shall be avoided.

Earth Embankments
Standards for earth embankments, as required, for holding ponds shall be as specified under Code 378 - Ponds.

Inlet and Outlets
The inlet to the holding pond may be of any type designed in accordance with appropriate standards.

There shall be no ungated outlet from the holding pond which can release runoff from less than a 10-year, 24-hour storm. An appropriate spillway or combination spillways shall be provided to protect the holding facilities from a 25-year, 24-hour storm.

Protection
Fencing and warning signs shall be provided as necessary to prevent children and others from using the facilities for purposes other than intended.

Design Criteria - Holding Tanks

Location
Holding tanks should be located as near the source of waste material as practicable giving due consideration to access to other facilities, cleaning and unloading. Locate where prevailing winds will minimize odor problems to neighbors and owner.

Materials and Design
Holding tanks shall be watertight structures of reinforced concrete, steel or other durable material, giving due consideration to the nature of the wastes. They shall be designed to prevent failure due to internal or external pressures including imposed surface loads and uplift pressure. All openings shall have tight fitting covers.

Size
Tanks shall have sufficient volume to temporarily store accumulated wastes plus any needed dilution water for the maximum period of time that such waste cannot be safely disposed of due to weather or operational restrictions. Determination of waste volume per day should be based on actual waste production for individual farm operations. The following table is a general guide to manure production for various animals:

DAILY MANURE PRODUCTION
(not including wash water or dilution water)

Animal	Cubic Feet/Day (Feces and Urine)
Dairy Cattle (1200 lbs.)	1.60
Beef Cattle (900 lbs.)	1.20
Horses (1000 lbs.)	0.90
Swine (150 lbs.)	0.15
Sheep (100 lbs.)	0.07
Poultry (4 lbs.)	0.0040

Appurtenant Equipment
Special liquid waste handling equipment shall be available to agitate the waste, remove it from the tank and carry it to selected areas for spreading. Commercial agitators, pumps and liquid manure tanks are available. Sprinkler irrigation systems, when properly designed and operated to safely dispose of liquid wastes can be utilized.

Plans and Specifications

Plans and specifications for Holding Ponds and Tanks shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION CANAL OR LATERAL

Definition

A permanent irrigation canal or lateral constructed to convey water from the source of supply to one or more farms. This includes open channels and elevated canals, but does not include Irrigation Field Ditches.

Purpose

Canals and laterals convey irrigation water from a source of supply to the beginning of a farm irrigation system. The conservation objectives are to prevent erosion or loss of water quality or damage to land, to make possible proper water use, and to convey water efficiently to minimize conveyance losses.

Conditions Where Practice Applies

All canals and laterals and related structures shall be planned as integral parts of an irrigation water conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Canals and laterals shall be located where they will not be subject to damage from side drainage flooding, or they must be protected from such damage.

All lands served by the canals and laterals shall be suitable for irrigation.

Water quality, supply, and delivery for the area served shall be adequate to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Unlined canals and laterals shall not be constructed on sites where the soils are excessively permeable. Where an excessively permeable soil site must be crossed, the canals and laterals shall be lined under the standards for ditch and canal linings.

Design Criteria

Capacity Requirements

The capacity of canals or laterals serving a farm or group of farms shall be determined by considering the delivery demands of all the farm irrigation systems served and the amount of water needed to

cover the estimated conveyance losses in the canal or lateral. Capacity must be enough to handle any surface runoff that is permitted to enter the canal.

Velocities

Canals and laterals shall be designed to develop velocities which are non-erosive for the soil materials through which the canal or lateral passes. Local information on the velocity limits for specific soils shall be used when available. When such information is not available, the maximum design velocities shall not exceed those shown in Figure 6-1, Chapter 6, Technical Release No. 25, Engineering Division, Soil Conservation Service, USDA.

Values of "n" in Manning's Formula

Canals and laterals must be designed with enough capacity to carry the required flows at the velocities that will be developed under the maximum probable retardance conditions.

For capacity design, the value of "n" shall be selected according to the material in which the canal or lateral is constructed, the alignment, and the hydraulic radius. The probable development of additional retardance because of weeds, or moss conditions shall also be considered.

For checking designs to see that velocities will not exceed permissible values, a Manning's "n" no greater than 0.025 shall be used, and applicable criteria in the Engineering Standard for Open Channels (Code 582) shall be followed.

Freeboard

Freeboard is the height of canal or lateral banks above the maximum water surface elevation that can be expected under the most severe design operating conditions. The required freeboard shall be at least one-third of the design flow depth (0.33d), and in no case shall it be less than 0.5 foot.

Side Slopes

Canals and laterals shall be designed to have stable side slopes. Local information on side slope limits for specific soils and/or geologic materials shall be used when available. When such information is not available, the design side slopes within the canal or lateral shall not be steeper than those shown in the following table.

Material	Side Slopes
Solid rock - cut section	1/4 : 1
Loose rock or cemented gravel - cut section	3/4 : 1
Heavy clay - cut section	1 : 1
Heavy clay - fill section	2 : 1
Sand or silt with clay binder - cut or fill section	1-1/2 : 1

Water Surface Elevation

Water surface elevations shall be designed to provide enough hydraulic head for successful operation of all ditches or other water conveyance structures diverting from the canal or lateral.

Canal or Lateral Banks

The top width of canal or lateral banks shall be enough to insure stability, prevent excessive seepage, and facilitate maintenance. It shall not be less than 2 feet and shall equal or exceed the flow depth.

Maintenance Access

Maintenance access as specified in the standard for practice Code 582 shall be provided along one or both sides of a canal or lateral as required for maintenance operations. Where the top of the bank or berm is to be used for a roadway, the width shall be enough for that purpose.

Protection from Surface Waters

Runoff water from adjacent areas shall be conveyed over or under the canal wherever practical. Where runoff is permitted to enter the canal or lateral, the side slopes shall be protected from erosion and provisions shall be made for proper disposal.

Related Structures

Plans for canal or lateral installations shall provide for adequate turnouts, checks, crossings, and other related structures needed for successful operation as a conservation irrigation facility. All related structures shall be designed and installed to meet SCS standards. Structures needed for the prevention or control of erosion shall be installed before the canal or lateral is put into operation.

Plans and Specifications

Plans and specifications for construction of Irrigation Canal or Lateral shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purposes.

See page S-320-1 for items to be considered in the development of specifications in addition to the above requirements.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION DITCH AND CANAL LINING
Non-reinforced Concrete

Definition

A fixed lining of impervious material installed in existing or newly constructed irrigation field ditch or irrigation canal or lateral. This includes shaping or reshaping of ditch and using material such as concrete, asphalt, or other durable lining.

Scope

This standard applies to concrete linings made of non-reinforced Portland Cement Concrete, cast in place in a preformed ditch or canal section, and does not include linings of pneumatically applied mortar.

This standard is restricted to installations in ditches or canals that have a bottom width not greater than 6 feet, a design capacity not greater than 100 c.f.s., and a maximum velocity of 15 feet per second.

This standard includes design and construction criteria for the ditch section as well as for the lining.

Purpose

The principal purposes of ditch and canal lining are to prevent water-logging of land, to maintain water quality, to prevent erosion, and to reduce water loss.

Conditions Where Practice Applies

Ditches and canals to be lined shall serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

The lands served by the lined ditches or canals shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries for the area served shall be enough to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall be located where they will not be subject to damage from side drainage flooding, or they shall be protected from such damage.

Non-reinforced concrete linings shall be installed only in well-drained soils or on sites where subgrade drainage facilities are installed with or before the lining. These linings shall not be installed on sites subject to severe frost heave or on sites where experience has indicated the sulphate salt concentration in the soil causes rapid concrete deterioration.

On sites where the sulphate concentration is more than 0.1 percent, concrete linings may be used only if made with special sulphate-resistant cements as follows:

Sulphate Concentration	Cement Type
Over 0.1%	II or V
Over 0.3%	V

Design Criteria

Capacity

A lined ditch or canal shall have enough capacity to meet its requirement as a part of the planned irrigation water distribution or conveyance system without danger of overtopping. Design capacity shall be based upon the following, whichever is greater:

1. Capacity shall be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.

2. Capacity shall be enough to provide an adequate irrigation stream for all methods of irrigation planned for use in the area served.

3. For design purposes, the capacity shall be considered to be equal to the capacity as computed with the Manning formula using a coefficient of roughness "n" of not less than 0.015.

Velocities

To avoid unstable surge flows, design velocities in excess of 1.7 times the critical velocity shall be restricted to straight reaches that discharge into a section or structure designed to reduce the velocity to less than critical velocity. The maximum velocity in these straight reaches shall be 15 feet per second.

Freeboard

The required freeboard varies with the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 inches.

This minimum freeboard requirement is based on the assumption that the finished channel bottom elevations will vary no more than 0.1 foot from the design elevations. If a construction deviation greater than 0.1 foot is to be permitted, the minimum freeboard shall be increased.

More freeboard shall be provided as required by slope velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

Water Surface Elevations

All lined ditches and canals shall be designed so the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface above the field surface will vary with the type of takeout structure or device used and the amount of water to be delivered through each. A minimum head of 4 inches shall be provided.

Lining Thickness

The thickness of canal linings must be established from engineering consideration on each job. Location, canal size, velocity, subgrade conditions, method of construction, operation, and climate shall be evaluated in establishing the thickness to be used. The minimum thickness for non-reinforced concrete linings in rectangular sections shall be 3 1/2 inches. For trapezoidal or parabolic sections the minimum thickness shall be as shown in Table I.

Table I

Minimum Required Thickness
For Non-reinforced Concrete Ditch And Canal Lining

Design Velocity	Climatic Area*		
	Mild	Moderate	Severe
Ft. per second	Minimum thickness--inches		
less than 6.0	1.5	2.0	2.5
6.0 to 9.0	2.0	2.0	2.5
9.0 to 12.0	2.5	2.5	2.5
12.0 to 15.0	3.0	3.0	3.0

* Climatic Areas -
Mild - Average January temperature above 40 degrees F.
Moderate - Average January temperature between 25 and 40 degrees F.
Severe - Average January temperature below 25 degrees F.

Ditch or Canal Side Slopes
Non-reinforced concrete linings generally are used in ditches and canals that have either a trapezoidal or parabolic cross-section.

They may be used in rectangular sections where the sidewall height will be not greater than 1 1/2 feet. Side slopes for usual construction methods shall not be steeper than shown below:

Hand-placed, formed concrete
Height of lining less than 1 1/2 feet - vertical

Hand-placed, screeded concrete
Height of lining less than 2 feet - 3/4 to 1
Height of lining more than 2 feet - 1 to 1

Slip form concrete
Height of lining less than 3 feet - 1 to 1
Height of lining more than 3 feet - 1 1/4 to 1

Ditch or Canal Banks
Ditch and canal banks shall be built up with earth to at least the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 inches above the top of the lining. Banks and berms shall be wide enough to insure stability of fills and to prevent excessive deposition in cut sections.

Where the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability.

Related Structures
Plans for ditch or canal lining installations shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation. These structures may be installed before, during, or after the lining placement. They must be constructed or installed in such a way as to not damage or impair the effectiveness of the lining.

Installation Requirements

Concrete used in ditch and canal linings shall be so proportioned that it is plastic enough for thorough consolidation and stiff enough to stay in place on the side slopes. A dense, durable product will be required. State standards shall specify a mix that can be certified as suitable to produce a minimum strength of at least 2000 lbs. per square inch.

The cement used shall be Portland Cement, Type I, II, or V, as specified for the job. The aggregate used shall have a maximum size not greater than one-half the specified lining thickness. Pozzolans may be used to replace not more than 15 percent of the cement by weight. All pozzolans shall be subject to approval of the engineer.

Concrete linings shall be constructed to at least the thickness shown on the plans and/or specified for the job.

Contraction joints, at least 1/4-inch wide, shall be cut transversely in the concrete to a depth of about one-third the thickness of the lining, at a uniform spacing not greater than 10 feet. Construction joints shall be butt type, formed square with the lining surface and at right angles to the ditch or canal.

Finished lining grades shall not vary above or below the design channel grade by more than the deviation assumed in computing the freeboard requirements and as specified for the job.

Plans and Specifications

Plans and specifications for construction of Non-reinforced Concrete Irrigation Ditch and Canal Lining shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purposes.

See page S-358-A-1 for items to be considered in the development of specifications in addition to the above requirements.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION DITCH AND CANAL LINING
Flexible Membrane

Definition

A fixed lining of impervious material installed in existing or newly constructed irrigation field ditch or irrigation canal or lateral.

Scope

This standard applies to buried membrane linings made of flexible materials, such as plastic, rubber, or asphalt. It includes design and construction criteria for the ditch section which affects the installation of the lining as well as for the lining itself.

Purpose

The principal purposes of ditch and canal linings with flexible membranes are to prevent waterlogging of land, to maintain water quality, and to reduce water loss.

Conditions Where Practice Applies

Ditches and canals to be lined shall serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

The lands served by the lined ditches or canals shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries for the area served shall be enough to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall be located where they will not be subject to damage from side drainage flooding, or they shall be protected from such damage.

Design Criteria

Capacity

A lined ditch or canal shall have enough capacity to meet its requirements as a part of the planned irrigation water distribution system without danger of overtopping. Design capacity shall be based on the following, whichever is greater:

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1. The capacity shall be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.

2. Capacity shall be enough to provide an adequate irrigation stream for all methods of irrigation planned for use in the area served.

<u>Velocities</u>

Velocities in canals or ditches lined with flexible membranes shall not exceed the non-erosive velocities for the soil material which is used for the protective cover or the material through which the canal or ditch passes, whichever is least. Local information on velocity limits for specific soils may be used when available. When such information is not available, the maximum design velocities shall not exceed those shown in Table 6-3, Chapter 6, Section 16, SCS National Engineering Handbook, except that in no case will the design velocities exceed 3 feet per second.

<u>Values of "n" in Manning's Formula</u>

Canals and laterals lined with flexible membranes must be designed with enough capacity to carry the required flows at the velocities that will be developed under the maximum probable retardance conditions.

For capacity design, the value of "n" shall be selected according to the material in which the canal or lateral is constructed, the alignment, hydraulic radius, and potential weed and moss hazard.

For checking designs to see that velocities will not exceed permissible values in erodible soils, a Manning's "n" no greater than 0.025 shall be used.

<u>Freeboard</u>

The required freeboard varies with the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 inches. This minimum freeboard requirement is based on the assumption that the finished channel bottom elevations will vary no more than 0.1 foot from the design elevations. If a construction deviation greater than 0.1 foot is to be permitted, the minimum freeboard shall be increased.

<u>Side Slopes</u>

Canals and ditches with buried membrane linings must be constructed with side slopes that will be statically stable. Slope requirements will vary with different types of cover material but in no case shall the side slopes be steeper than 3:1.

Protective Cover

Membrane linings shall be protected by an earth or an earth and gravel covering not less than 6 inches thick, except that in areas subject to traffic by livestock the minimum thickness shall be 9 inches. The bottom 3 inches of cover shall not be coarser than silty sand.

Membrane Thickness

The required membrane thickness is dependent upon the expected sub-grade conditions, the hydrostatic forces which will be acting on the membrane, and the susceptibility of the lining to damage during or after installation. The minimum nominal thickness shall be:

BURIED LINERS

	Asphalt	Plastic Sheeting	Non-Reinf. Rubber	Reinf'd Rubber
Coarse Soils - SM-SP-SW	225 mil	8 mil	30 mil	20 mil
Gravels - GC-GM-GP-GW		12 mil	30 mil	30 mil

Water Surface Elevations

Water surface elevations shall be designed to provide enough hydraulic head for successful operation of all ditches or other water conveyance structures diverting from the canal or reservoir. Water surface elevations at all field takeout points shall be high enough to provide the required flow onto the field surface. A minimum head of 4 inches shall be provided.

Materials

Flexible membrane liners shall equal or exceed the physical requirements shown in Engineering Specifications for Materials, pages 358-B-5 through 358-B-9.

Installation Requirements

Placing Membranes

Plastic and rubber membranes shall be carefully spread in a relaxed condition over the raked and smoothed sub-grade. Rubber sheets may be pulled out smooth, but all liners shall be installed in a relaxed state. For polyethylene film, care shall be taken to insure that at least 5 percent slack is provided. Prefabricated asphalt membranes shall be pulled out so they lay flat on the sub-grade.

Where the width or length of the lining specified is such as to require placing together of sheets, all joints shall be watertight, and the strength of the bonded seam in any direction shall not be

less than 80 percent of the breaking strength (ultimate tensile strength) of the membrane when the specimen is pulled in shear.

Anchoring Membrane

Side edges - Small anchor trenches about 10 inches wide and 12 inches deep shall be used to anchor the sides of the membrane. These trenches shall be located along the berm on both sides of the canal. They shall be a minimum of 4 inches back on the berm from the top of the side slope and at the elevation required to maintain the specified freeboard. The membrane shall conform to the trench shape and shall extend a minimum of 8 inches up the side opposite the canal. The trenches shall be carefully backfilled and compacted after the membrane is in place.

Upstream end - The upstream end of each section of plastic or rubber membrane shall be anchored in a trench dug across the canal. This trench shall be about 10 inches wide and 12 inches deep, and shall connect with the 2 side anchor trenches. The upstream end of the membrane section shall lap down a minimum of 12 inches into this transverse trench. After the membrane is in place, the trench shall be carefully backfilled with selected compacted material.

Special - Prefabricated asphalt membranes shall be anchored at the upstream end of the lining section and at such intermediate points as are specified for individual jobs.

Downstream end - No anchors will be required at the downstream end of membrane sections. The downstream end of the membrane shall be lapped a minimum of 3 feet over the anchored upstream end of the next section. Placement of the protective cover material will secure the joint.

Placing Protective Cover

Material to be used as protective cover on membrane linings shall be free of large clods and sharp rocks and shall be carefully placed to the specified depth without damaging the membrane.

Plans and Specifications

Plans and specifications for construction of Flexible Membrane Irrigation Ditch and Canal Lining shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purposes.

See page S-358-B-1 for items to be considered in the development of specifications in addition to the above requirements.

ENGINEERING SPECIFICATIONS FOR MATERIALS

The flexible sheets or films to be used as buried membrane linings in irrigation ditches or canals shall be suitably constructed of high quality ingredients and shall be certified by the manufacturer to be suitable for this intended use. Figmented polyvinyl or polyethylene plastics, rubber, asphalt, or similar materials that are highly resistant to bacteriological deterioration will be acceptable base materials for buried membrane linings. If the membranes are reinforced, an inorganic reinforcing material shall be used.

The fabricated membranes shall be uniform throughout and shall be free from dirt, oil, foreign matter, pits, tears, holes, or other defects which would affect their serviceability. They shall be packaged so as to prevent damage from rough handling during shipment and so as to facilitate placement at the job site. Each package shall be marked with the name of the material, the manufacturer's name or symbol, the quantity contained therein, and the thickness or unit weight of the material.

Flexible membrane liners of the materials shown shall equal or exceed the physical requirements as listed in Table I, (Polyvinyl Chloride Plastic Sheeting); Table II, (Unreinforced Rubber Sheeting); Table III, (Nylon Reinforced Rubber Sheeting); and Table IV (Polyethylene Plastic Film).

The test for soil burial will be as follows:

The soil burial test shall be performed by preparing six 6-inch long by 1-inch wide test specimens, 3 in machine direction and 3 in transverse direction, as done for tensile strength testing ASTM D882, and burying them vertically to a depth of about 5 inches in soil rich in cellulose destroying micro-organisms. At the end of 30 days, the tensile strength and ultimate elongation shall be determined. The soil used for specimen burial shall be composted soil prepared according to usual greenhouse practice and should have a pH of 6.5 to 7.5. The moisture content of the soil shall be maintained between 25 to 30 percent on an ovendry basis. The test shall be performed with the soil containers stored in a room maintained between 90 to 100 degrees F. The microbiological activity of the soil shall be frequently checked by burying untreated 10-ounce cotton duck for 1- and 2-week periods. Satisfactory activity is indicated by tensile strength losses above 70 percent of strength in 1 week and above 90 percent in 2 weeks.

TABLE I

POLYVINYL CHLORIDE PLASTIC SHEETING

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS	TEST METHOD
Tensile Strength, Each Direction Minimum psi	2000	ASTM-D-882
Elongation, Each Direction, Minimum %	250	ASTM-D-882 (Method A)
Volatility, % Maximum Loss	0.7	ASTM-D-1203
Water Extraction, Maximum % Weight Loss	0.5	ASTM-D-1239
Tear Resistance (Elmendorf) Each Direction - Minimum Grams/Mil	160	ASTM-D-1922
Compost Resistance		Page 358-B-6
Tensile Retained, Each Direction Minimum %	95	
Elongation retained, Each Direction Minimum %	80	
Commercial Field Splice Strength		
Shear Force, % of Minimum Tensile	80	Commercial field splice, one inch wide strip, pulled in shear at 10" per minute, after 7 days cure at room temperature

TABLE II

UNREINFORCED RUBBER SHEETING

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS TYPE "A"	REQUIREMENTS TYPE "B"	TEST METHOD
Tensile Strength, Minimum psi=	1200	1200	ASTM-D-412
Modulus at 300% Elongation, Minimum psi	600	600	ASTM-D-412
Ultimate Elongation, Percent Minimum	300	300	ASTM-D-412
Shore "A" Hardness	60±10	60±10	ASTM-D-2240
Ozone Resistance - Procedure "A"			ASTM-D-1149
No cracks - 50 pphm - 100°F - 20% Elongation	7 days		ASTM-D-518
No cracks - 50 pphm - 100°F - 100% Elongation		14 days	
Heat Aging - 7 days at 212°F			ASTM-D-573
Tensile strength retained, % of original	75	75	
Elongation retained, % of original	75	75	
Water Vapor Permeability - at 80°F Perm-mils	.002	.05	ASTM-E-96 (Procedure BW)
Tear Resistance, lbs. per inch., minimum	150	150	ASTM-D-624 Die "B"
Dimensional Stability, 7 days at 212°F, % of change in length or width	±0.5	±0.5	
Commercial Field Splice Strength			
Shear force, % of minimum tensile	60	60	Commercial Field Splice, one inch wide strip pulled in shear at 10" per minute, after 7 days cure at room temp.

NOTE: Type "A" sheeting is recommended for general purpose outdoor usage.

Type "B" material is suggested where an extreme outdoor environment requires a highly weatherable lining.

TABLE III

NYLON REINFORCED RUBBER SHEETING

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS UP TO 20 MILS THICKNESS	REQUIREMENTS 20 MILS THICK & GREATER	TEST METHOD
Breaking Strength, Minimum lbs./inch			ASTM-D-751
Warp Direction	75	100	
Fill Direction	75	100	
Ultimate Elongation, % Maximum			ASTM-D-751
Warp Direction	30	30	
Fill Direction	30	30	
Ozone Resistance - Procedure "B"			ASTM-D-1149
50 pphm - 100°F	7 days	7 days	ASTM-D-518
Hydrostatic Strength After Ozone Exposure (7 days) (Mullen) % Retained	100	100	Fed. Spec. CCC-T-191b, Method 5512, ASTM-D-518
Heat Aging - 7 days at 212°F			ASTM-D-573
Tensile strength retained, % of orig.	90	90	
Elongation retained, % of original	90	90	
Tear Resistance - Minimum Warp or Fill Direction, Lbs.	8	8	ASTM-D-751 (Tongue)
Hydrostatic Burst (Mullen), psi Minimum	100	175	ASTM-D-751
Dimensional Stability, 7 days at 212°F % change in length or width	± 1.0	± 1.0	*

TEST DESCRIPTION	REQUIREMENTS UP TO 20 MILS THICKNESS	REQUIREMENTS 20 MILS THICK & GREATER	TEST METHOD
Low Temperature Flexibility (Optional) No cracking or flaking	-40°F	-40°F	Fed. Spec. CCC-T-191b Method 5874
Commercial Field Splice Strength Shear Force, % of Minimum Tensile	75	75	Commercial field splice one inch wide strip, pulled in shear at 10"/ minute, after 7 days cure at room temperature

*One foot square sample, 10" bench marks in warp and fill direction, placed on Aluminum or Stainless plate in changing air over.

TABLE IV

POLYETHYLENE AND ETHYLENE CO-POLYMER PLASTIC FILM

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS TYPE I POLYETHYLENE	TYPE II CO-POLYMER	TEST METHOD
Tensile Strength Each Direction, Minimum Avg. psi	1800	2000	ASTM-D-882 Method "A"
Ultimate Elongation Each Direction, Minimum Avg. %	500	500	ASTM-D-882 Method "A"
Impact Resistance Minimum Average, Grams/Mil	45	65	ASTM-D-1709 Method "B"
Water Vapor Permeability - Perm-Mils	0.7	1.5	ASTM-E-96
Tear Resistance (Elmendorf) Each Direction, Minimum Grams/Mil	80	80	ASTM-D-1922
Compost Resistance			
Tensile retained, Each Direction, Minimum %	95	95	Page 358-B-6
Elongation retained, Each Direction, Minimum %	80	80	
Luminus Transmittance % Maximum	1.0	1.0	CS-238, paragraph 6.8

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION DITCH AND CANAL LINING
Galvanized Steel

Definition

A fixed lining of impervious material installed in existing or newly constructed irrigation field ditch or irrigation canal or lateral.

Scope

This standard applies to linings made of galvanized steel installed in a preformed ditch or canal section.

Linings covered by this standard are restricted to ditches having characteristics as follows:

1. Bottom Widths - Not to exceed 30 inches
2. Velocities - Not to exceed 15 ft./sec.

This standard covers both the ditch section and the steel lining.

Purpose

The principal purposes of ditch and canal lining are to prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water losses.

Conditions Where Practice Applies

Ditches and canals to be lined shall be located to serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

The lands served by the lined ditches or canals shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall be located where they will not be subject to damage from side drainage flooding, or they shall be protected from such damage.

Steel linings shall not be installed in areas high in salt or other chemical concentrations injurious to galvanized steel unless the liners are protected with coatings or anodic protection specifically designed to protect the liner from these chemicals.

Design Criteria

Capacity

A lined ditch or canal shall have enough capacity to meet its requirement as a part of the planned irrigation water distribution or conveyance system without danger of overtopping. Design capacity shall be based upon the following, whichever is greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak consumptive use of the crops in the area served.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

For design purposes, the carrying capacity of steel-lined ditches and canals shall be considered to be equal to the capacity as computed by the Manning equation, using a coefficient of roughness "n" of not less than 0.013.

Velocities

Design velocities in excess of 1.7 times the critical velocity shall be restricted to straight reaches that discharge into a section or structure designed to reduce the velocity to less than the critical velocity. The maximum velocity in these straight reaches shall be 15 feet per second.

Freeboard

The required freeboard varies with the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 inches.

When velocities are within ± 30 percent of critical, the freeboard shall be at least 6 inches. The minimum freeboard requirement is based on the assumption that the finished channel bottom elevations will vary no more than 0.1 foot from the design elevations. Construction deviations greater than 0.2 foot shall not be permitted. If a construction deviation greater than 0.1 foot is to be permitted, the minimum freeboard shall be increased an additional 3 inches.

Additional freeboard shall be provided as required by slope, velocity, depth of flow, alignment, cbstructions, curves, and other site conditions.

Water Surface Elevations
All lined ditches and canals shall be designed so the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. A minimum head of 4 inches shall be provided.

Ditch or Canal Pad or Foundation
Ditch and canal banks shall be built up with earth to a height sufficient to support the full height of the lining and to provide an anchorage for the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 inches above the top of the lining.

Berms and ditch banks shall be wide enough to prevent excessive deposition in cut sections and to insure support of the lining in fill sections. The minimum width shall be one foot. Where the bank or berm is to be used as a roadway, the minimum top width shall be 8 feet.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability. They shall not be steeper than 1 1/2 horizontal to 1 vertical.

Related Structures
Plans for ditch or canal lining installations shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation.

Structures shall be constructed or installed in such a way as to not reduce the capacity or freeboard of the ditch, or damage or impair the effectiveness of the lining.

All structures shall meet SCS standards and specifications for the type of structure used.

Bulkheads formed to fit the lining, and with sufficient size to extend at least 12 inches into the earthen ditch pad for the entire width of the ditch lining, shall be installed at the beginning and end of the lining section and at intervening points as needed to provide adequate anchorage.

Materials
Galvanized lining material shall meet the requirements on page 358-C-5 following.

Installation Requirements

Fill material and backfill of over-excavated areas shall be placed in horizontal lifts of 8 inches maximum thickness and shall be uniformly compacted to the density of the surrounding material to the top of the ditch lining.

Lining grades shall at no place vary more than 0.2 foot above or below the design grade, and deviations greater than 0.1 foot will be allowed only in canals for which the design freeboard is 6.0 inches or more.

Opposite sides of the lining shall be within 0.1 foot of the same elevation.

Plans and Specifications

Plans and specifications for construction of Galvanized Steel Irrigation Ditch and Canal Lining shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purposes.

See page S-358-C-1 for items to be considered in the development of specifications, in addition to the above requirements.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Galvanized sheet steel used in the linings, battens, related structures, and accessories shall conform to ASTM A 525, coating class 1.25 oz/ft^2, or Federal Specification QQ-S-775C, Type 1, Class d.

Minimum thickness of the lining shall be 24 gage for individual sheets up to 84 inches wide and 22 gage for wider sheets. The edges of the steel linings shall be rolled or pressed into a shape that will provide added strength at the corners and firm anchorage into the ditch at the top of the lining.

Minimum thickness of steel used for bulkheads and related structures shall be 20 gage in accord with ASTM A 446, Grade C, Steel.

Fasteners used in assembly of liners and structures shall be zinc or cadmium plated.

Sealer material used shall be able to withstand temperature variations to be expected at the site.

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SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION FIELD DITCH

Definition

A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields within the farm distribution system. Includes open channels and elevated ditches. Does not include Irrigation Canal or Lateral that delivers water to the farm.

Scope

This standard covers open channels of 25 cubic feet per second or less capacity formed in and with earth materials. It does not include canals and laterals or ditches which are constructed and removed during a season and ditches shaped or constructed for lining installation.

Purpose

The conservation objectives for field ditches are to prevent erosion or loss of water quality or damage to the land, to make possible proper irrigation water use, and to convey water efficiently to minimize conveyance losses.

Conditions Where Practice Applies

Field ditches shall be planned and located as integral parts of an irrigation water distribution system designed to facilitate the conservation use of soil and water resources.

Water quality, supply, and delivery for the area served shall be adequate to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Field ditches shall be constructed in earth material that contains enough fines to prevent excessive seepage losses, and where shrinkage cracks will not endanger the ditch. The sealing effect of sediment carried in the irrigation water may be considered.

Design Criteria

Capacity

Field ditches shall have the capacity to deliver to the field a flow adequate to meet:

1. The design peak consumptive use of the crops to be grown in the field with proper provision made for the expected field irrigation efficiency.

2. The largest irrigation stream required for the irrigation methods planned for the field.

The capacity shall be increased further to provide for the additional flow required to compensate for the ditch seepage loss and to safely carry surface runoff from adjacent lands which must be transported to wasteways or overflow points. For capacity design, the value of "n" shall be selected according to the material in which the ditch is constructed, the alignment and hydraulic radius, and additional retardance because of weeds or moss conditions.

Velocity

Field ditches shall be designed to develop velocities which are non-erosive for the soil materials through which they pass. Local information on the velocity limit for specific soils shall be used when available. When such information is not available, the maximum design velocity shall not exceed those in Figure 6-1, Chapter 6, Technical Release No. 25, Engineering Division, Soil Conservation Service, USDA.

Field ditches shall be designed with enough capacity to carry the required flows at the velocities that will be developed under the maximum probable retardance conditions.

For checking designs to see that velocities will not exceed permissible values, a Manning's "n" no greater than 0.025 shall be used, and applicable criteria in the Engineering Standard for Open Channels (Code 582) shall be followed.

Cross Section

Freeboard in field ditches shall be not less than one-third of the maximum design depth of water. Side slopes shall be stable. The top width of banks as measured at the elevation providing the required freeboard shall be not less than 12 inches and shall equal or exceed the flow depth.

When a field ditch is to be constructed on top of an embankment, the side slopes of the embankment shall not be steeper than:

Height to water surface on centerline of fill	Steepest allowable side slopes of fill
Under 3 feet	1 1/2 : 1
3 feet - 6 feet	2 : 1
Over 6 feet	2 1/2 : 1

Related Structures
Erosion or water control structures, culverts, diversions, or other related structures needed to supplement the field ditch shall be designed and installed to meet Soil Conservation Service standards for the particular structure and type of construction involved.

Plans and Specifications

Plans and specifications for construction of Irrigation Field Ditches shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purposes.

See page S-388-1 for items to be considered in the development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION LAND LEVELING

Definition

Reshaping the surface of land to be irrigated to planned grades. Does not include Drainage Land Grading or Land Smoothing.

Purpose

Land leveling for irrigation is done to permit uniform and efficient application of irrigation water without erosion, loss of water quality, or damage to land by waterlogging, and at the same time to provide for adequate surface drainage.

Conditions Where Practice Applies

All lands to be leveled shall be suitable for use as irrigated land and for the proposed methods of water application.

Water supplies and irrigation deliveries to the area to be leveled shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Soils shall be deep enough so that, after the needed leveling work is done, an adequate, usable root zone remains which will permit satisfactory crop production with proper conservation measures. Limited areas with shallower soils may be leveled to provide adequate irrigation grades or a better field arrangement. The finished leveling work must not result in exposed areas of highly permeable materials that would inhibit proper distribution of water over the field.

All leveling work shall be planned as an integral part of an overall farm irrigation system to facilitate the conservation use of soil and water resources. The boundaries, elevations, and direction of irrigation of individual field leveling jobs shall be such that the requirements of all adjacent areas in the farm unit can be met.

Design Criteria

Field Grades

Where the use of more than one method of water application or one kind of crop is planned, the land must be leveled to meet the requirements of the most restrictive method and crop.

All leveling work must be designed within the slope limits required for the methods of water application to be used, to provide for the removal of excess surface water and control erosion from rainfall.

Reverse grades in the direction of irrigation shall not be permitted.

Slope Requirements to Control Erosion from Rainfall
Design field grades shall be such that the erosion from rainfall can be controlled within the limits permissible for conservation farming.

Slope Requirements for Level Irrigation Methods

Slope in direction of irrigation - The maximum fall in the length of run shall not exceed one-half the design depth of application for a normal irrigation.

Cross-slope - The difference in elevation across an individual border strip shall not exceed 0.10 foot.

Slope Requirements for Graded Irrigation Methods

Slope in direction of irrigation - The maximum slope in the direction of irrigation where rainfall erosion is not a significant problem shall be as follows:

1. Furrows - 3 percent

2. Corrugations - 8 percent

3. Borders for non sod-forming crops, such as alfalfa or grain - 2 percent

4. Borders for erosion-resistant grass or grass-legume crops, or for non sod-forming crops on sites where water application by the border method will not be required until after good crop stands have been established - 4 percent.

Variation in slope - Slopes may be uniform in the direction of irrigation or may increase or decrease. On slopes of more than 0.5 percent where leveling designs provide for increasing or decreasing slopes, the maximum grade in an irrigation run shall be no more than twice the minimum. Short, level sections are permissible at the upper or lower end of irrigation runs to facilitate water control or reduce runoff.

Cross-slope - (1) Borders: The maximum cross-slope shall be 0.1 foot per border strip width. (2) Furrows and corrugations: The allowable cross-slope for furrows and corrugations depends largely upon the stability of the soil, the size of furrows that are expected

to be used, and the rainfall pattern in the area. Cross-slopes must be such that "break throughs" from both irrigation water and runoff from rainfall are held to a minimum.

Requirements for Surface Drainage

Farm irrigation systems shall include plans for removing excess irrigation and storm water from the field. Leveling designs must provide field elevations and field grades that will permit proper functioning of the planned drainage facilities.

Maximum Field Elevation

All leveling work shall be designed so the highest point in the field is far enough below the elevation of the water source to permit delivery of needed irrigating streams onto the field surface. The field elevation shall be at least 4 inches below the water surface elevation at the point of delivery.

Plans and Specifications

Plans and specifications for Irrigation Land Leveling shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purposes.

Excavation and fill material required for or obtained from such structures as ditches, ditch pads, and roadways shall be planned as a part of the overall leveling job and the appropriate yardage included when balancing cuts and fills and determining borrow requirements.

See page S-464-1 for items to be considered in the development of specifications in addition to the above requirements.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
Aluminum Tubing, Plastic Tape Coated

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies only to buried aluminum pipelines, coated with plastic tape on the exterior surface.

This standard covers (1) the specifications for the aluminum tubing and plastic wrapping to be used, (2) the design criteria, and (3) the minimum installation requirements for the pipeline.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to land, to make possible proper water use, and to reduce water conveyance losses.

Conditions Where Practice Applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution system that has been designed to facilitate the conservation of water on a farm or group of farms.

All lands served by the pipelines shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Design Criteria

Working Pressure

The maximum permissible working pressure in the line will be determined by the following equation:

$$P = \frac{2St}{d}$$

Where:

S = 7500 pounds per square inch

P = Maximum working pressure in pounds per square inch

d = Inside diameter of tube in inches

t = Tube nominal wall thickness in inches

Capacity

Design capacity shall be based on whichever of the following is greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak consumptive use of the crop.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

For design purposes, the value of "n" in Manning's formula shall be considered to be 0.01, except where joints, connections, condition of the pipe, etc. indicate that a higher value is required.

Stands for Low Pressure Lines Open to the Atmosphere

Stands will be used wherever water enters the pipeline, to avoid entrapment of air, to prevent surge-pressures, collapse due to vacuum failure, and prevent pressure from exceeding the design working stress of the pipe. The stand will be designed to:

1. Allow a minimum of one foot of freeboard. The stand height maximum above the centerline of the pipeline must not exceed the maximum working head of the pipe.

2. Have the top of each stand at least 4 feet above the ground surface except for surface gravity inlets which shall be equipped with trash racks and covers.

3. Have downward water velocities in stands not in excess of 2 feet per second. In no case shall be inside diameter of the stand be less than the inside diameter of the pipeline.

The cross sectional area of stands may be reduced above a point 1 foot above the top of the upper inlet but in no case shall the reduced cross section be such that it would produce an average velocity of more than 10 feet per second if the entire flow were discharging through it.

When the water velocity of an inlet pipe exceeds 3 times the velocity of the outlet, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 inches and shall be constructed so that the bottom is at least 24 inches below the invert of the outlet pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 feet per second. Suitable provisions for cleaning sand traps shall be provided.

Gate stands will be of sufficient dimensions to accommodate the gate or gates required and will be large enough to make the gates accessible for repair.

Float valve stands shall be of sufficient size to provide accessibility for maintenance and to dampen surge.

Construction shall be such as to insure that vibration from the pump discharge pipe is not carried to the stand.

Vents for Low Pressure Lines Open to the Atmosphere

Vents must be designed into the system to provide for the removal of air and prevention of vacuum collapse. They shall:

1. Have a minimum freeboard of 1 foot above the hydraulic grade line. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum working head of the pipe.

2. Have a cross sectional area at least one half the cross sectional area of the pipeline (both inside measurements) for a distance of at least 1 pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 inches in diameter.

3. Vents shall be located:

   a. At the downstream end of each lateral.

   b. At summits in the line.

   c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees.

   d. Immediately below the pump stand if the downward velocity in the stand exceeds 1 foot per second.

4. A combined air-release-vacuum-release valve may be used in lieu of an open vent. Air-vacuum release valves shall have a 2-inch minimum diameter. Two-inch valves shall be used for lines of 6-inch diameter or less, 3-inch valves for diameters from 7 inches through 10 inches, and 4-inch valves for 12-inch pipe.

Outlets

Appurtenances to deliver water from a pipe system to the land, a ditch, or any surface pipe system shall be known as outlets. Outlets shall have a capacity to deliver the required flow, (1) to the hydraulic grade line of a pipe or ditch, or (2) to a point at least 6 inches above the field surface.

Drain Requirements

Provision shall be made to completely drain the pipeline. Drainage outlets should be provided at all low points in the system and may either discharge into a dry well or to a point of lower elevation. If these gravity discharge points are unavailable, provision shall be made to empty the line by pumping.

Check Valves, Pressure Relief, Air Release, and Vacuum Release for High Pressure Closed Systems

A check valve shall be installed between the pump discharge and the pipeline where detrimental backflow may occur.

A pressure relief valve shall be installed at the pump location when excessive pressures can be developed by operating with all valves closed. Also in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures could be developed, a surge chamber or pressure relief valve shall be installed.

Pressure relief valves shall be no smaller than 1/4-inch nominal size for each diameter inch of the pipeline, and shall be set at a maximum of 5 p.s.i. above the pressure rating of the pipe.

Pressure relief valves or surge chambers shall be installed at the end of the pipeline when needed to relieve surge.

Air release and vacuum release valves shall be placed at all summits in the pipeline and at the end of the line when needed to provide a positive means of air release or escape.

Air release and vacuum release valve outlets of at least 1/2-inch nominal diameter shall be used in lines of 4 inches or less in diameter, at least 1-inch outlets shall be used in lines 5-8 inches in diameter, and at least 2-inch outlets in lines 10-16 inches in diameter.

Joints and Connections

All connections shall be constructed to withstand the working pressure of the line without leakage and leave the inside of the line free of any obstruction which would reduce the line capacity below design requirements. All fittings such as risers, ells, tees, couplings, and reducers shall preferably be of similar metal. However, if dissimilar metals are used, proper protection against galvanic corrosion,

such as separating dissimilar metals with a rubber or plastic insulator, shall be taken. The connection between the pump discharge pipe and the aluminum line shall be made with a suitable insulating material such as rubber or plastic.

Quality of Water

Water quality tests shall be made for all aluminum pipeline installations. Copper content in excess of 0.02 p.p.m. will produce nodular pitting and rapid deterioration of the pipe, if water is allowed to remain stagnant.

Materials

Pipe and coating materials shall equal or exceed the physical requirements of this standard under Engineering Specifications for Materials.

Installation Requirements

Corrosion Protection

All aluminum tubing installed under this standard shall be wrapped with a plastic tape for corrosion protection in accordance with the following specifications:

1. Tubing exterior - surface protection
   The surface of the tubing to be coated shall be cleansed of all foreign material such as oil, grease, dirt, mud, etc. Any knurls, burrs, or other sharp points will be removed by filing, peening, or wire brushing.

2. Coating
   The plastic tape, or combination of plastic tape and other materials used to aid in protecting the tubing and bonding the plastic tape to the tubing shall have the minimum physical and electrical properties listed under "Quality of Tape and Bonding Agent," Engineering Specifications for Materials.

3. Plastic Coating of Fittings and Connections
   Where possible, fittings shall be coated at the fabricating shop in such a manner as to provide a uniform, intimately bonded coating allowing no voids or bridging of coating to metal surface. The surface preparation and the coating materials employed shall conform to the minimums set forth under "Corrosion Protection."

   Contours or offsets occurring in pipe or fittings of such a magnitude so as to cause "bridging" of the tape coating shall be prepared in the following manner:

   a. Clean and prepare metal surface as specified under "Corrosion Protection."

b. Prime entire surface to be coated allowing no skips or voids.

c. Wrap with molding or filler tape in manner prescribed by manufacturer of such tape or apply a filler compound to the irregular surface and overwrap with tape. In all cases, primer, molding tape, and filler compound shall be compatible and recommended by those manufacturers with whose products they are employed.

4. Field Wrapping of Joints
Clean and prepare metal surface as prescribed. Remove sufficient overwrap to allow for a minimum of 2-inch overlap onto the "inplace" coating. Remove any scuffed or loosely bonded coating material.

Prime entire surface to be coated including the 2-inch area of "inplace" coating.

Beginning with a "square" or perpendicular wrap, spirally wrap the entire primed area maintaining firm tension and overlap as recommended by the manufacturer. In any case, overlap shall not be less than 1/2 inch ending with a "square" or perpendicular wrap. Tape shall be applied free of voids, folds, or wrinkles.

Where irregular contours or offsets are encountered that are conducive to "bridging" of the coating to the metal, thereby preventing an intimate voidfree bond, the techniques set forth under "Plastic Coating of Fittings and Connections" shall apply.

Marking
Each pipe section shall be plainly marked, after wrapping, with the manufacturer's symbol or name, size of pipe, wall thickness and working pressure or class.

Handling of Plastic Coated Tubing
Tubing shall be handled in a manner so as to prevent abrasion to the coating during transportation and handling. It shall not be dropped, dragged, or rolled on the ground. If it becomes necessary to move the pipe longitudinally on the ground or in the ditch it shall be done in such a manner as not to injure the tubing or coating. When stockpiled the coated tubing shall be carefully piled and blocked so as to prevent damage to the coating.

Placement
All pipe shall be placed deep enough below the land surface to protect it from hazards imposed by traffic crossings, farm operations, freezing temperatures, or soil cracking. Two feet minimum cover shall

be provided except in soils subject to deep cracking, where the cover shall be a minimum of 3 feet. Extra fill may be placed over the pipeline to provide the minimum depth of cover if the top width of the fill is not less than 10 feet and side slopes are not steeper than 6:1.

The width of the trench shall be at least 6 inches greater than the diameter of the pipe being installed. When trenches are excavated in soils containing rock or other hard materials which might damage the pipe or coating material, they shall be excavated deeper than required, and then backfilled to grade with selected fine earth or sand.

The line may be assembled above ground or in the ditch taking care to align the joints at time of placement. At each joint, which will be observed during testing for leakage, scoop out sufficient dirt to allow for final coating and taping. Every care shall be taken to prevent impact or scuffing against the sides of the trench.

Depending on the type of joint used between lengths of tubing it may be necessary to partially backfill the ditch to hold the tubing in place during testing. If this is done the partial backfill will be on the body of the tubing, but not at the joints. Thrust blocks or anchors shall be used at line ends or bends in the line where necessary.

Installation of Minimum-Wall-Thickness Tubing

In cases where the aluminum tubing is 6 inches or larger in diameter and has a wall thickness less than that specified in Column A of Table I, the installer shall take additional precautions to prevent negative pressures from causing collapse of the tube under initial filling, testing, and normal service conditions.

Testing

Testing the pipe shall be accomplished before backfilling. The pipe shall be filled with water taking care to bleed the air and slowly build up the pressure to the maximum working pressure. The pipeline shall be walked and all leaks repaired before proceeding with back-fill. Pipelines shall be tested at the working pressure.

It shall be demonstrated that all pipelines function properly at design capacity. At or below design capacity there shall be no objectionable surge or water hammer. Objectionable flow conditions shall include (1) continuing, unsteady delivery of water, (2) damage to the system, and (3) detrimental overflow from vents, stands, or valves.

Backfilling

The initial backfill shall be of selected material, free from rocks, stones or hard clods. This initial fill shall be compacted firmly

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around the pipe. Care must be taken to avoid deformation or displacement of the pipe during this phase of the operation.

When water packing is used the pipeline shall be filled with water. The initial backfill, before wetting, shall be of sufficient depth to insure complete coverage of the pipe after consolidation has taken place.

Water packing is accomplished by adding water in such quantity to thoroughly saturate the initial backfill without inundation. After saturation, the valves shall be closed and the pipeline shall remain full until final backfill is made.

The wetted fill must be allowed to dry until firm before final backfill is begun.

Final backfill material shall be free of large rocks or boulders, and shall be added to the trench in a manner that will leave the fill at ground level after settling.

Any special requirements of the pipe manufacturer or the installer shall be strictly observed.

Inspection

After final assembly of the line and taping of the joints and connections, the entire system shall be visually inspected for breaks or ruptures in the plastic coating. All breaks or ruptures shall be marked and repaired in the following manner:

1. Remove overwrap (if necessary) from the area adjacent to the damage.

2. Trim off scuffed or broken material and brush on a thin film of primer over damaged area and about 2 inches beyond, onto the undamaged tape. Apply a patch cut to fit the entire primed area. Smooth into place without wrinkles.

The continuity of the plastic coating shall be of such quality that all tubing, joints and fittings, after assembly shall be capable of passing an inspection test conducted with a spark discharge holiday detector at 1500 volts.

Certification and Guarantee

The Installing Contractor shall certify that his installation complies with requirements of this standard. He shall furnish a guarantee against defective workmanship and materials for 2 years from date of installation.

Plans and Specifications

Plans and specifications for construction of Aluminum Tubing Irrigation Pipelines shall be in keeping with the Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Quality of Aluminum Tubing

The tubing shall be rigid and composed of aluminum alloys that contain properties and characteristics found suitable for irrigation service by the Sprinkler Irrigation (SIA) and the American Society of Agricultural Engineers (ASAE), "Minimum Standards for Irrigation Equipment," approved January 1957.

All alloys used for buried irrigation lines shall be clad on the inside of the tubing with an alloy which is anodic to the base alloy to a thickness of at least 5 percent of the nominal wall thickness of the tubing.

Tubing with nominal wall thickness as listed in Column A of Table I shall be acceptable for all installations where the operating pressure does not exceed 150 p.s.i. The minimum permissible wall thickness of the tubing and the associated maximum permissible working pressures are given in Column B of Table I. Should tubing be used with wall thickness between the range listed for the pipe size, the maximum working pressure shall not exceed that obtained by the equation specified under "Working Pressure."

TABLE I

Tube Diameter Inches	Column A Nominal Wall Thickness, inches Acceptable All Installations to 150 p.s.i. working pressure	Column B Min. Wall Thickness & Assoc. Maximum Working Pressure	
		Inches	p.s.i.
2	.050	.05	150
3	.050	.05	150
4	.050	.05	150
5	.052	.05	150
6	.058	.05	125
7	.064	.05	108
8	.072	.05	94
9	.082	.058	97
10	.094	.058	87
12	.110	.058	73

Quality of Tape and Bonding Agent

The coating that is applied to the tubing shall be of a plastic or rubber type material, or both, capable of withstanding the moisture and soil conditions to which it will be subjected on buried aluminum tubing.

TABLE II

MINIMUM PHYSICAL PROPERTIES
FOR THE APPLIED THICKNESS OF PLASTIC CORROSION PREVENTIVE TAPE

TEST DESCRIPTION	TEST METHOD
1. Minimum plastic or plastic and bonding adhesive agent, applied thickness, inches - 0.010	ASTM D1000
2. Breaking strength, lb/in width - 20	ASTM D1000
3. Elongation of plastic coating at break percent - 50 - 300	ASTM D1000
4. Adhesion to aluminum, oz/in - 22	ASTM D1000
5. Tear test	
Machine direction, lbs. - 4	ASTM D1004
Cross direction - lbs. - 4	ASTM D1004
6. Dielectric Breakdown	
After standard conditions, volts - 7000	ASTM D1000
After water immersion, volts - 6000	ASTM D1000
7. Resistance to impact, cm. - 60	See page 432-A-10
8. Puncture resistance, lbs. - 8.0	See page 432-A-10
9. Salt water resistivity, ohm/ft - 2 x 10^{11}	See page 432-A-11
10. Resistance to abrasion, milligrams - max. 300	See page 432-A-11

Test Methods

Resistance to Impact

Apparatus - The following apparatus shall be required:

1. A steel ball bearing with a diameter of 1-3/8 inches weighing 173.5 ± 1.0 grams.

2. A suitable device to release the ball in free-fall.

3. A solid steel plate at least 2 inches by 2 inches by 1/2 inch on which the specimen is placed.

4. A steel roller (See ASTM D-1000, Section 35 (c)).

5. An ohmmeter.

6. An electrolytic (saturated) solution of cupric chloride in butyl-cellosolve.

Test Procedure and Results

A 2-inch by 2-inch specimen shall be placed adhesive side down on the steel plate and the roller passed over it once in each direction at a rate of approximately 2 inches per second. The steel ball shall be dropped from 60 cm. on the 10 mil specimens and from 145 cm. on the 20 mil specimens. A few drops of the electrolytic solution shall be applied to the indentation and one of the probes of the ohmmeter placed in the solution and the other probe on the steel plate. A puncture occurs if the ohmmeter reads 50 megohms or less. Six of 10 ball drops must not puncture at specified drop heights in order to pass this test.

Puncture Resistance

Apparatus - The following apparatus shall be required:

1. A cross-head type testing machine which conforms to Section 35a of ASTM D-1000 and is capable of a speed of 2 inches per minute.

2. A test fixture shown in Figure 1.

Test Procedure and Results

Five 1-inch by 3-inch specimens shall be prepared from each 1-inch roll. The testing machine shall be zeroed to compensate for the weight and frictional drag of the test fixture. The specimen shall be placed adhesive side down over the hole in the lower fixture and securely clamped with the clamping device provided. The driven jaw shall move at a rate of 2 inches per minute. The force required to puncture the specimen shall be recorded in pounds. The average of 5 tests shall be reported as the puncture resistance.

Salt Water Resistivity

Apparatus - The following apparatus shall be required:

1. A 10-inch by 13-inch sheet of #20 gage sheet metal.

2. Six pint cans with covers - L.D. Approximately 3.25 inches.

3. Four 1 1/2 volt #6 dry cells.

4. A short circuit jack box containing 6 short circuit jacks.

5. One and one-half pints saturated NaCl solution.

6. An electrometer with appropriate shunt to measure 10^{-3} to 10^{-14} amps.

7. Roller, sealing material, and miscellaneous wire, solder, etc.

Test Procedure and Results

Two 4-inch by 13-inch specimens shall be placed adhesive side down on the 10-inch by 13-inch sheet. A roller shall be passed over the specimens until all air is excluded. The bottoms shall be removed from the pint cans. Three cans shall be evenly spaced bottom side down on each specimen and sealed to the surface of the specimen. The 4 dry cells shall be connected in series. The 10-inch by 13-inch sheet shall be connected to the negative terminal of the battery bank. Each pint can shall be connected to the positive terminal of the battery bank through a short circuit jack so that an ammeter can be inserted into each individual circuit without interrupting the current flow. Each can shall then be filled 1/4 full with saturated salt solution and the can cover placed on the can to prevent evaporation. The resistivity of the coating in ohms-ft. shall be determined after 15 weeks by measuring the current flowing to each can. The current shall be measured by inserting the electrometer and shunt into the circuit for each can using the short circuit jacks. The resistivity of each sample shall be calculated according to the following formula:

$$\text{Resistivity (ohm-ft.)} = \frac{\text{(Voltage applied in volts) (Area in ft.}^2\text{)}}{\text{(Current in amperes) (Thickness in ft.)}}$$

The average of the six determinations shall be reported as the salt water resistivity.

Resistance to Abrasion

Apparatus - The following apparatus shall be required:

1. Taber abraser, model 140, and parts or equivalent.

2. Analytical balance.

3. A steel roller (See ASTM D-1000, Section 35 (c)).

Test Procedure and Results

An approximate 4-inch by 4-inch 2-ply specimen shall be placed adhesive side down to cover the flat specimen plate and the steel roller passed over it once in each direction at a rate of approximately 2 inches per second. The specimen plate with the attached 2-ply specimen shall be weighed on an analytical balance to the nearest milligram and then placed in the Taber abraser. The abraser wheels, covered with fresh NEMA sandpaper strips and loaded at 1000 grams per wheel, shall abrade the specimen for 400 cycles. The specimen plate shall be reweighed to the nearest milligram. The weight loss in milligrams shall be reported as Abrasion Resistance.

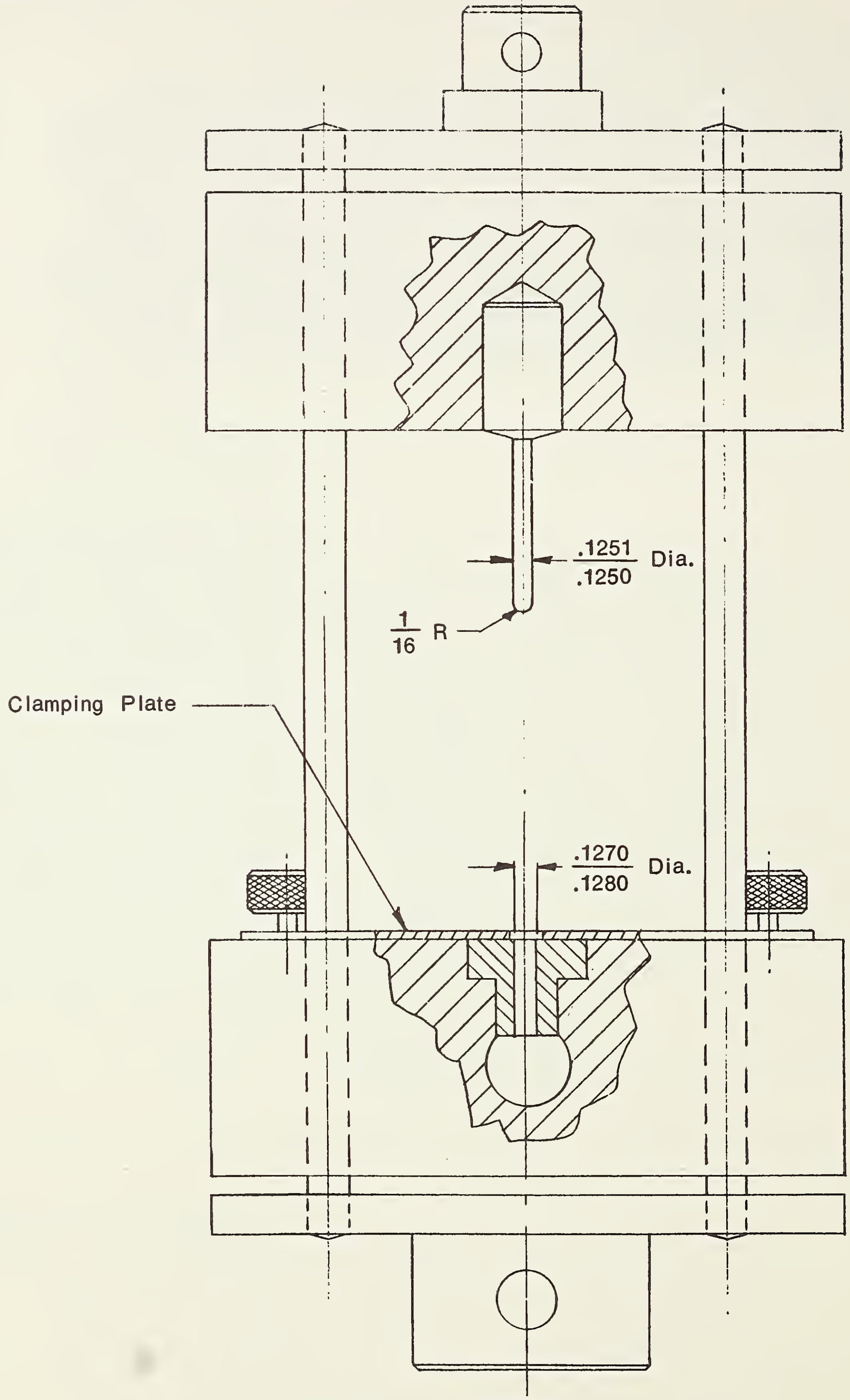

Figure 1.

Puncture Resistant Test Unit

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
Asbestos-Cement

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies to buried asbestos-cement pipelines with rubber gasket joints.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions Where Practice Applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All lands served by the pipelines shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Design Criteria

Pressure

The maximum design working pressure shall be based on a safety factor of no less than 3.0 applied to the certified hydrostatic proof pressure as determined in accordance with Section 4, ASTM C 500. Hydrostatic test pressures for standard working pressure classification shall be as specified in Table 1.

For pipelines to be used principally for conveyance, where adequate hydraulic analysis of surge, water hammer or other pressure change is made on the basis of anticipated operating conditions, and where

combined loading stresses are determined, a safety factor of 3.0 or less may be applied to the hydrostatic proof pressure to determine the maximum design working pressure.

The minimum acceptable working pressure classification shall be 15 p.s.i.

Pipelines may be designed either closed or open to the atmosphere.

<u>External Load Limit</u>
A safety factor of at least 1.50 shall be applied to the certified 3-edge bearing test in computing allowable heights of fill over the pipe. The earth loads shall be computed by the method outlined in Soil Conservation Service Technical Release No. 5.

<u>Capacity</u>
Design capacity shall be based on whichever of the following is greater:

1. The capacity shall be sufficient to deliver the volume of water needed to meet the peak consumptive use of the crop.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all planned methods of irrigation.

<u>Friction Loss</u>
For design purposes, the pipeline friction loss shall be no less than that computed by the Hazen-Williams formula using a roughness coefficient, c, of 140.

<u>Check Valves</u>
Where detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

<u>Pressure Relief, Vacuum Release, and Air Release Valves - Pipelines Closed to the Atmosphere</u>
A pressure relief valve shall be installed at the pump location when excessive pressure can be developed by operating with all valves closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures could be developed, a surge chamber or pressure relief valve shall be installed close to the check valve or the side away from the pump.

Pressure relief valves for all classes of asbestos cement pipe except Class 15 Irrigation Pipe shall be no smaller than 1/4-inch nominal size for each diameter inch of the pipeline, and shall be set at a maximum of 5 p.s.i. above the pressure rating of the pipe.

Pressure relief valves for Class 15 Irrigation Pipe shall have a flow capacity of equal to the pipeline design flow rate with a pipeline pressure no greater than 50 percent higher than the permissible working head for the pipe. Such pressure relief valves shall be marked with the pressure at which the valve starts to open; and adjustable pressure relief valves shall be sealed or otherwise altered to prevent changing of the adjustment from that marked on the valve.

A pressure relief valve or surge chamber shall be installed at the end of the pipeline when needed to relieve surge.

Pressure relief valves do not function as air release valves and shall not be used as substitutes for air release valves or to perform the air release function of vents or valves.

Air release and vacuum release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve when needed to provide a positive means of air entrance or escape.

Air release and vacuum release valve outlets shall be at least 1-inch nominal diameter when specified for lines of 5- to 8-inch diameter, at least 2-inch outlets for lines of 10- to 16-inch diameter, at least 4-inch outlets for lines of 18- to 28-inch diameter, at least 6-inch outlets for lines of 30- to 36-inch diameter, and at least 8-inch outlets for lines of 38- to 48-inch diameter.

For pipelines larger than 16-inch diameter, 2-inch air release valves may be used in place of the sizes indicated above if they are supplemented with vacuum release valves that will provide vacuum release capacity equal to the sizes shown.

Stands and Vents - Lines Open to the Atmosphere

General.
Stands shall be placed at each inlet to the irrigation pipe system and at such other points as required. All stands shall serve as vents in addition to their other functions. All stands will be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. All stands will comply with the following:

1. Avoid entrainment of air.

2. Allow 1 to 5 feet of freeboard.

3. Conform to ASTM C 76 or C 478 when concrete pipe greater than 24 inches in diameter is used for a stand.

4. When cast in place, contain steel reinforcing on not more than 1-foot centers to provide steel areas equal to or greater than the least values specified for Class II (1500-D-Ultimate) pipe in ASTM C 76.

5. The tops of all stands shall be at least 4 feet above the ground surface, except that if visibility is not a factor, the top may be lower if covered or equipped with trash guards.

Pump stands.
Pump stands shall be one of the following types:

1. Concrete box stands with vertical sides, suitably reinforced.

2. Non-tapered stands of concrete pipe, suitably reinforced.

3. Non-tapered concrete pipe stands, capped and having a vent pipe of the height required to take care of hydraulic gradient plus freeboard.

4. Steel cylinder stands mortared to short concrete pipe riser.

The centerline of the pump discharge pipe shall have a minimum vertical offset from the centerline of the outlet pipe equal to the sum of the diameters of the inlet and outlet pipes. This may be through the side of the stand or over the top.

Construction shall be such as to insure that the vibration from the pump discharge pipe is not carried to the stand.

Velocities in stand.
Downward water velocities shall not exceed 2 feet per second. In no case shall such velocities exceed the average pipeline velocity.

If the size of a pump stand is decreased above the pump discharge pipe, the top vent portion shall be of such inside cross-sectional area that, if the entire flow of the pump were discharging through it, the average velocity will not exceed 10 feet per second.

Gate stands.
Gate stands shall:

1. Be constructed of concrete pipe or shall be cast-in-place concrete. Reinforcing requirements listed under Stand Requirements will apply.

2. Have dimensions sufficient to accommodate the gate or gates required.

3. Serve as vents.

4. Be of such dimensions that gates are accessible for repair.

Float valve stands.
Float valve stands shall be of sufficient diameter to provide accessibility for maintenance and to dampen surge.

Sand traps.
Pump stands or gravity inlets serving as sand traps shall have a minimum inside diameter of 30 inches and shall be constructed so that the bottom is at least 24 inches below the invert of the outlet pipeline. Suitable provisions for cleaning sand traps shall be provided.

Vent requirements.
Vents must be designed into the system to provide for the removal of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 foot above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum working head of the pipe.

2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least 1 pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 inches in diameter.

3. Be located:

    a. At the downstream end of each lateral.

    b. At summits in the line.

    c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees.

    d. Immediately below the pump stand if the downward velocity in the stand exceeds 1 foot per second.

<u>Draining and Flushing Requirements</u>
Provisions shall be made for draining the pipeline completely where a hazard is imposed by freezing temperatures or drainage is specified for the job or recommended by the pipe manufacturer.

Where provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be thus provided by gravity, provisions shall be made to empty the line by pumping.

A suitable valve shall be installed at the distal end of the line when flushing to remove sediment is required.

Outlets
Appurtenances to deliver water from a pipe system to the land, a ditch, or any surface pipe system shall be known as outlets. Outlets shall have a capacity to deliver the required flow:

1. To the hydraulic gradeline of a pipe or ditch.

2. To a point at least 6 inches above the field surface.

3. To an individual sprinkler or lateral line at the design operating pressure of the sprinkler or lateral line as the case may be.

Thrust Control
Abrupt changes in pipeline grade, horizontal alignment, or reduction in size require an anchor or thrust blocks to absorb any axial thrust of the pipeline.

Where thrust blocks or anchors are used, they shall be constructed of concrete or soil cement with at least one part cement to 12 parts soil of sandy loam or coarser texture. Thrust blocks shall fill the space between the pipe and the undisturbed earth at the side of the trench on the outside of bends to the full height of the outside diameter of the pipe, shall have a minimum thickness of 6 inches and a length in feet perpendicular to the direction of thrust equal to:

$$(98\ HD\ \mathrm{Sin}\ 1/2\ a)/B$$

Where:

H = maximum working head in feet

D = inside diameter of the pipe in feet

B = allowable passive pressure of the soil in pounds per square foot, and

a = deflection angle of the pipe bend.

Materials
All materials shall conform to the minimum requirements of this Standard under Engineering Specifications for Materials.

Installation Requirements

Placement
All pipe shall be placed deep enough below the land surface to protect it from hazards imposed by traffic crossings, farm operations, freezing temperatures, or soil cracking. Minimum cover shall be 2 feet except in soils subject to deep cracking for which minimum cover shall

be 3 feet. For Class 15 Irrigation Pipe (15# I.P.) minimum cover shall be 2 1/2 feet and maximum cover shall be 4 feet.

Extra fill may be placed over the pipeline to provide the minimum depth of cover if the top width of fill is not less than 10 feet and the side slopes are not steeper than 6 to 1.

Where trenches are excavated in soils containing rock or other hard materials, where soils are subject to appreciable swelling and shrinking on wetting and drying, or where the trench bottom is unstable, the trenches shall be over-excavated and backfilled with selected materials as needed to provide a suitable base. If water is in the trench, that water shall be drained away, and laying the pipe postponed until a suitable base has been obtained.

The pipe trench shall be reasonably straight. The maximum deflection in any one coupling shall not exceed 5 degrees for pipe sizes up to 12 inches and 3 degrees for larger sizes. Short radius curves may be introduced into the alignment by using short sections of pipe and giving each coupling no more than the maximum allowable deflection.

Trench width for Class 15 Irrigation Pipe (15# I.P.) shall be no wider than the pipe diameter plus 18 inches.

Testing

Pipelines shall be tested for leaks by observing their normal operation any time after the contractor has installed all appurtenances on the pipeline and indicated the pipeline as ready for testing.

The line shall be inspected in its entirety while the maximum working pressure is maintained. All visible leaks shall be promptly repaired and the line re-tested.

It shall be demonstrated by testing that the pipeline will function properly at design capacity. At or below design capacity there shall be no objectionable surge or water hammer. Objectionable flow conditions shall include continuing unsteady delivery of water, damage to the pipeline, and detrimental discharge from control valves.

Certification and Guarantee

The pipe shall be certified by the manufacturer for compliance with this standard.

The installing contractor shall certify that his installation complies with the requirements of this standard. He shall furnish a written guarantee designed to protect the owner against defective workmanship and materials over a period of not less than 2 years, and shall name the source of the asbestos-cement pipe used.

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Plans and Specifications

Plans and specifications for Asbestos Cement Irrigation Pipelines shall be in keeping with the Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Pipe and Couplings

Asbestos-cement irrigation pipe shall be composed of an intimate mixture of Portland Cement ASTM C150 or of Portland Blast Furnace Slag Cement ASTM C595 or of Portland-Pozzolan Cement ASTM C595, silica and asbestos fiber and shall be free from organic substances. The material shall be formed under pressure and thoroughly cured to produce pipe meeting the requirements of these specifications.

Coupling sleeves shall be made of asbestos-cement and shall be machined with rubber ring retaining grooves so that when the joint is assembled a water-tight seal is provided. Assembly of pipe and coupling shall provide necessary end separation.

The types of pipe shall be known as Types I, II, and III corresponding to the chemical requirements given.

Type I - for use including those sites where moderately aggressive water, and soil of moderate sulfate content are expected to come in contact with the pipe and when tested in accordance with Sections 14 and 15 of ASTM C500, the amount of uncombined calcium hydroxide shall not exceed 3.0 percent.

Type II - for general use including those sites where either moderately or highly aggressive water or water and soil of both moderate and high sulfate content are expected to come in contact with the pipe, and when tested in accordance with Sections 14 and 15 of ASTM C500, the uncombined calcium hydroxide shall not exceed 1.0 percent.

Type III - for use only on those sites where contact with aggressive waters and sulfates are not expected. There are no chemical requirements for Type III pipe.

Asbestos cement irrigation pipe (SCS 432-B, I.P.) shall be classified in accordance with its allowable maximum operating pressure: 15, 25, 75, 90 and 125. Asbestos cement pressure pipe (ASTM C296) shall be classified in accordance with its pressure class: 100, 150 and 200. Asbestos cement transmission pipe (ASTM C668) shall be in classifications representing numerically one-tenth of the minimum hydrostatic strength.

Each standard, random, or short length of pipe and coupling sleeve shall be hydrostatically tested by the manufacturer prior to shipment and shall have sufficient strength to withstand the internal hydrostatic pressure prescribed in Table I when tested in accordance with Section 4 of ASTM C500.

Each length of pipe shall have sufficient flexural strength to withstand, without failure, the total load prescribed in Tables 2a and 2b for the classes and sizes listed, when tested in accordance with Section 7, ASTM C500.

Asbestos-cement pipe shall have a minimum crushing strength as indicated in Tables 3a and 3b, when tested in accordance with the crushing test as specified in Section 10 of ASTM C500.

Each length of pipe shall be marked with the manufacturer's identification, nominal size, maximum working pressure, and date of manufacture.

Each coupling shall be marked with the manufacturer's identification, nominal size, and letter "T" to indicate that it has been hydrostatically tested.

Gaskets

The rubber ring gaskets required for proper assembly of pipe and coupling shall conform to the manufacturer's dimensions and tolerances. They shall equal or exceed the specifications for gaskets in ASTM D1869.

Accessories

The valves, asbestos-cement or metal fittings, etc., shall be of adequate capacity and suitable quality to withstand the design pressures and shall be installed in accordance with the manufacturer's recommendation to meet the service requirements of the pipeline.

Table 1

Applied Hydrostatic Proof Pressure

Applicable Specification No.	Classification	Working Pressure p.s.i.	Applied Proof Pressure p.s.i.	Size Range ins.
SCS 432-B Irrigation Pipe	15# I.P. 1/	15	45	10-36
	25# I.P.	25	75	3-36
	75# I.P.	75	225	3-36
	90# I.P.	90	270	3-36
	125# I.P.	125	375	3-36
ASTM C 296	Class 100	100	350	3-36
	Class 150	150	525	3-36
	Class 200	200	700	3-36
ASTM C 668	Classification number is one tenth of minimum hydrostatic strength 2/	One fourth of minimum hydrostatic strength 2/	Three fourths of minimum hydrostatic strength 2/	6-42

1/ I.P. = Irrigation Pipe
2/ Minimum hydrostatic strength as defined in Section 7, C 668

Table 2a

Minimum Flexural Strength

(Total Applied Load, Lbs.)

Nominal Size	Working Pressure Classification						
	432-B Irrigation Pipe				ASTM C 296		
Inches	25#	75#	90#	125#	Class 100	Class 150	Class 200
3	300	500	-	750	755	853	915
4	600	1000	-	1300	1200	1460	1860
5	900	1500	-	2000	-	-	-
6	1300	2000	2000	3300	2800	3700	4900
8	2500	3700	4000	6000	5330	7600	10130

Note: Based on 9-foot span for all sizes - See ASTM C 500, Section 7

Table 2b

Minimum Flexural Strength

(Total Applied Load in Lbs.)

Nominal Size ins.	Pipe Classification C 668								
	30	35	40	45	50	60	70	80	90
6	-	-	2300	2500	2800	3200	3700	4000	4900
8	3700	4400	5100	5700	6400	6900	7600	8800	10100

Note: Based on 10-foot span for both sizes - See Section 7, ASTM C 500

Table 3a

Minimum Crushing Strength

(Lbs. Per Lineal Foot)

Nominal Size Inches	Working Pressure Classification							
	Irrigation Pipe					ASTM C 296		
	15#	25#	75#	90#	125#	Class 100	Class 150	Class 200
3	-	1500	2300	-	4400	4600	6700	8800
4	-	1100	1900	-	4200	4100	5400	8700
5	-	1000	1650	-	4000	-	-	-
6	-	1000	1400	1600	3700	4000	5400	9000
8	-	1300	1650	2000	4000	4000	5500	9300
10	1200	1500	1900	2100	4300	4400	7000	11000
12	1200	1500	2200	2300	4600	5200	7600	11800
14	1200	1500	2600	-	5000	5200	8600	13500
16	1400	1500	2750	-	5400	5800	9200	15400
18	1500	1800	2900	-	5800	6500	10100	17400
20	1800	2000	3100	-	6400	7100	10900	19400
24	2000	2400	3500	-	7500	8100	12700	22600
30	2400	3000	4100	-	9000	9700	15900	28400
36	3000	3600	5000	-	10500	11200	19600	33800

Table 3b

Minimum Crushing Strength

(Lbs. per Lineal Foot)

Nominal Size ins.	Pipe Classification C 668								
	30	35	40	45	50	60	70	80	90
6	-	-	2400	3200	4000	4700	5400	6700	9000
8	2000	2400	2800	3400	4000	4800	5500	7400	9300
10	2000	2500	3000	3500	4500	5500	7000	9000	11000
12	2000	2500	3000	4000	5200	6400	7800	10000	12200
14	2000	2500	3000	4000	5200	7000	8800	11000	13500
15	2300	2800	3300	4300	5500	7400	9300	12000	14500
16	2500	3000	3500	4500	5800	7500	9500	12400	15400
18	2500	3000	4000	5000	6500	8500	11000	14000	18000
20	2500	3500	4500	5500	7100	9500	12000	15000	20000
21	2500	3500	4500	5800	7300	9700	12500	16000	21000
24	2800	3800	5000	6200	8100	11000	15000	19000	24000
27	3500	4200	5500	7000	8800	12500	16500	20500	27000
30	3500	4500	6000	7500	9700	13500	18000	22500	30000
33	3500	5000	6500	8000	10500	14500	19500	24500	33000
36	4000	5000	7000	9000	11200	16000	21000	26000	36000
39	4200	5300	7500	9700	12000	17200	22500	28000	39000
42	4300	5700	8000	10500	13000	18500	24000	30000	42000

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
Non-reinforced Concrete

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard covers the installation of low or intermediate pressure non-reinforced concrete irrigation pipelines with rubber gasket joints, mortar joints, or cast-in-place without joints. It includes pipelines with stands and vents open to the atmosphere, and pipelines not open to the atmosphere but provided with pressure relief valves.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to the land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions Where Practice Applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All lands served by the pipelines shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be employed.

Concrete pipelines shall not be installed on sites where the sulphate salt concentration in the soil or soil water exceeds 1.0 percent. On sites where the sulphate concentration is more than 0.1 percent but not more than 1.0 percent, concrete pipe may be used only if the pipe is made with Type V cement or Type II cement whose tricalcium aluminate content does not exceed 5.5 percent.

Cast-in-place pipe shall be used only in stable soils which are capable of being used as the outside form for approximately the bottom half of the conduit.

Design Criteria

A. Pressure

Definition - Maximum working head is defined as the working head plus freeboard.

Rubber gasket joints - The maximum working head shall not be more than 1/3 the certified hydrostatic test pressure determined by the test procedure prescribed in ASTM C 505 and shall not exceed 50 feet for sizes 6 through 12 inches, 40 feet for sizes 15 through 18 inches, 30 feet for sizes 21 and 24 inches, and 25 feet for 26 through 30 inches in diameter.

Mortar joints - The maximum working head shall not be more than 1/4 the certified hydrostatic test pressure as determined by the hydrostatic test procedure as prescribed in ASTM C 118 and shall not exceed 40 feet for sizes 6 and 8 inches, 35 feet for sizes 10 and 12 inches, 30 feet for sizes 14 through 24 inches, and 25 feet for sizes 26 through 30 inches.

Cast-in-place pipe - The maximum working head will not exceed 15 feet above the centerline of the pipe.

B. External Load Limit

A safety factor of at least 1.25 shall be applied to the 3-edge bearing test in computing allowable heights of fill over the precast pipe.

C. Capacity

Design capacity shall be based on whichever of the following is greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak consumptive use of the crop.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

D. Outlets

Appurtenances to deliver water from the pipe system to the land, to a ditch, or to any surface pipe shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow (1) to the hydraulic grade line of the pipe or ditch, or (2) to a point at least 6 inches above the field surface.

E. Friction Loss

For design purposes, friction head losses shall be no less than those computed by the Manning equation using a coefficient of roughness "n" of 0.011 for rubber gasket jointed pipe, 0.012 for mortar jointed pipe, and 0.014 for cast-in-place pipe.

F. Anchors

Abrupt changes in pipeline grade or alignment require either:

1. A stand of diameter greater than the pipeline.
2. An anchor to absorb any axial thrust of the pipeline.
3. A larger diameter pipe placed horizontally or placed vertically and capped below ground or a capped below ground in-place structure.

An abrupt change shall be considered to be: (a) an angle of 45 degrees or greater when the maximum working head is under 10 feet; (b) an angle of 30 degrees or greater when the maximum working head is between 10 and 20 feet; and (c) an angle of 15 degrees or greater when the maximum working head is greater than 20 feet.

Where a vent is used in lieu of a pump stand at the entrance to a rubber gasket irrigation pipeline, a suitable anchor shall be constructed to resist end thrust.

Anchors shall be constructed of either:

1. Concrete poured to fill the space between the pipe and the undisturbed earth at the side of the trench on the outside of bends.
2. Soil cement with at least one part of cement to 12 parts of soil of sandy loam or coarser texture, similarly placed and thoroughly tamped.

The anchors shall be to the full height of the outside diameter of the pipe and shall have a minimum thickness of 6 inches and a length in feet normal to the direction of thrust equal to:

$$98 \frac{HD}{B} \sin \frac{a}{2}$$

where:

H = maximum working head in feet,
D = inside diameter of the pipe in feet,
B = the allowable passive pressure of the soil in pounds per square foot, and
a = the deflection angle of the pipe bend.

The pipe shall be clean and wet when placing the anchor, to provide a good bond between anchor and pipe. Where adequate soil tests are not available, the allowable passive soil pressure shall be considered to be 500 pounds per square foot.

G. Design of Pipelines Open to the Atmosphere

General - Stands shall be placed at each inlet to a concrete irrigation pipe system and at such other points as required. All stands shall serve as vents in addition to their other functions. Stands shall be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline.

All stands will comply with the following:

1. Avoid entrainment of air.

2. Allow 1 to 5 feet of freeboard

3. Conform to ASTM C 76 or C 478 when concrete pipe of diameter greater than 24 inches is used.

4. When cast in place, contain steel reinforcing on not more than 1-foot centers to provide steel areas equal to or greater than the least values specified for Class II (1500-D-Ultimate) pipe in ASTM C 76.

5. Have tops at least 4 feet above the ground surface, except that if visibility is not a factor, the tops may be lower when covered or equipped with trash guards.

6. Be of such dimensions that downward water velocities shall not exceed 2 feet per second, and in no case shall downward velocities exceed the average pipeline velocity.

7. Be of a size and design to permit repairs and cleaning.

Check valves shall be installed in the pump discharge line where detrimental backflow from the pipeline can occur.

Construction shall be such as to insure that the vibration from the pump discharge pipe is not carried to the stand or pipeline.

Pump stands - Pump stands shall be one of the following types:

1. Concrete box stands with vertical sides, suitably reinforced.

2. Non-tapered stands of concrete pipe, suitably reinforced.

3. Non-tapered concrete pipe stands, capped and having a vent pipe of the height required to take care of hydraulic gradient plus freeboard.

4. Steel cylinder stands mortared to short concrete pipe riser.

5. A vent in combination with a direct connection, in lieu of a pump stand, providing:

   (a) The pipeline joints are rubber gasket type, exclusively,
   (b) Freeboard requirements under General are met,
   (c) The velocity, direction and turbulence of flow does not prevent the release through the vent of entrained air, and
   (d) The discharge from the pump does not enter through the vent.

For pump stands of types 1, 2, 3 and 4 above, and when the pump discharge velocity exceeds 3 times the outlet velocity, the centerline of the pump discharge pipe shall have a minimum vertical offset from the centerline of the outlet pipe equal to the sum of the diameters of the inlet and outlet pipes. The pump discharge may enter through the side of the stand or over the top.

All pump stands having a decreased size above the pump discharge, and the vent of type 5 above, shall be of such a cross-sectional area that if the entire flow of the pump were discharged out through the top of the stand or type 5 vent, the average velocity would not exceed 10 feet per second.

<u>Gate Stands</u> - Gate stands shall:

1. Be constructed of concrete pipe or shall be cast-in-place. Reinforcing requirements listed under Stand Requirements will apply.

2. Have dimensions sufficient to accommodate the gate or gates required.

3. Serve as vents.

4. Be of such dimensions that gates are accessible for repair.

<u>Float Valve Stands</u> - Float valve stands shall be of sufficient diameter to provide accessibility for maintenance and to dampen surge.

<u>Sand Traps</u> - Pump stands or gravity inlets serving as sand traps shall have a minimum inside diameter of 30 inches and shall be constructed so that the bottom is at least 24 inches below the invert of the outlet pipeline. Suitable provisions for cleaning sand traps shall be provided.

Vent Requirements - Vents shall be designed into the system to provide for the removal of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 foot above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum working head of the pipe.

2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least 1 pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 inches in diameter.

3. Be located:

    a. At the downstream end of each lateral.

    b. At summits in the line.

    c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees.

    d. Immediately below any stand if the downward velocity in the stand exceeds 1 foot per second.

Air-Vacuum Release Valves - An air-vacuum release valve may be used in lieu of an open vent, but either a vent or an air-vacuum release valve shall be provided at each of the locations in item 3 of Vent Requirements, above. Air-vacuum release valve outlets shall have a 2-inch nominal minimum diameter. Two-inch outlets shall be used for lines of 6-inch diameter or less, 3-inch outlets for lines of 7-inch to 10-inch diameter, and 4-inch outlets for lines of 12-inch diameter.

Air release or vacuum release valves shall not be used in lieu of open stands nor shall they be used in lieu of a vent where the vent is used in combination with a direct pump connection.

H. Design of Pipelines Not Open to the Atmosphere

General - Pressure relief valves may be used on non-reinforced concrete pipelines as an alternative to design with stands open to the atmosphere. A pressure relief valve shall serve the pressure relief function of the open stand or vent for which it is an alternative.

Pressure relief valves do not function as air release valves and shall not be used as substitutes for such valves where release of entrapped air is required.

The flow capacity of pressure release valves shall be the pipeline design flow rate with a pipeline pressure no greater than 50 percent above the permissible working head for the pipe.

Marking and Setting - Pressure relief valves shall be marked with the pressure at which the valve starts to open. Adjustable pressure relief valves shall be sealed or otherwise altered to prevent changing of the adjustment from that marked on the valve.

Other Design - Air-vacuum release valves shall be used at each location specified in Vent Requirements, Pipelines Open to the Atmosphere. The size of outlet for air-vacuum release valves shall be as specified in Air-Vacuum Release Valves, Pipelines Open to the Atmosphere.

Design of check valves, vibration control, gate stands, and sand traps shall be as specified for Pipelines Open to the Atmosphere.

I. Pipe Material

Mortar joint pipe - Non-reinforced concrete pipe laid with mortar joints shall conform to or exceed the requirements of ASTM C 118.

Rubber gasket joint pipe - Non-reinforced concrete pipe laid with rubber gasket joints and the rubber gaskets shall conform to or exceed the requirements of ASTM C 505.

Cast-in-place pipe - Non-reinforced cast-in-place concrete pipe shall conform to or exceed the requirements of ASTM C 477, edition of August 31, 1965.

Installation Requirements

Placement

The pipeline shall be placed deep enough below the land surface to protect it from the hazards imposed by traffic crossing, farming operations, freezing temperatures or soil cracking. The minimum depth of cover shall be 18 inches for pipe sizes up to and including 12 inches in diameter. For pipelines greater than 12 inches in diameter, the minimum depth of cover shall be 24 inches.

Where trenches are excavated in soils containing rock or other hard materials, or in soils subject to appreciable swelling and shrinking on wetting or drying, or where the trench bottom is unstable, the trenches shall be over-excavated and backfilled with selected materials to sufficient depth to provide a suitable base. If water is in the trench, that water shall be drained away or controlled in such a manner as not to damage the joint mortar and a suitable base shall be maintained.

Openings into mortar joint and cast-in-place concrete pipelines shall be covered to prevent air circulation except when work is actually in progress. Such openings shall be kept closed until the pipeline is completed and is to be filled with water.

Mortar Joint Pipelines

There shall be an initial backfill of soil around the pipe and covering the pipe to a depth of at least 6 inches for the full width of the trench and not more than 7 sections of pipe behind the laying. If laying ceases for 2 hours or more, the initial backfill shall be brought up to and cover the last completed joint. Nothing in this section shall prohibit the complete backfilling while mortar bands are still plastic. If complete backfilling is not done at this time, the completion shall be delayed at least 20 hours. To prevent damage, the trench shall be backfilled to the minimum specified cover or 2 feet, whichever is less, before the pipe is filled with water.

Mortar joints shall be protected from drying out. If the soil used in the initial backfill is not thoroughly moist, a suitable membrane over the mortar shall be used. Membranes consisting of one layer of Kraft paper or paper cut from cement sacks or membranes conforming to ASTM C 171 or C 309 shall be considered suitable.

Cast-In-Place Pipelines

Cast-in-place pipe shall be installed, cured, backfilled and tested in accordance with the requirements set forth in ASTM C 477, edition of August 31, 1965.

Testing

It shall be demonstrated that all rubber gasket jointed, mortar jointed, and cast-in-place pipelines function properly at design capacity. At or below design capacity there shall be no objectionable surge or water hammer. Objectionable flow conditions shall include:

1. Continuing unsteady delivery of water,
2. Damage to the system, and
3. Detrimental overflow from vents or stands.

Pipelines shall be tested for leaks by observing their normal operation any time after a period of two weeks of continuous wetting. All visible leaks shall be repaired. Seasonal cold water shall not be used for this test.

Plans and Specifications

Plans and specifications for Non-reinforced Concrete Irrigation Pipelines shall be in keeping with the Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

April 1971

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
High Pressure Underground Plastic

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies to underground thermoplastic pipelines from 1/2 inch to 12 inches in diameter that are closed to the atmosphere, and that are subject to internal pressures up to 315 pounds per square inch.

The standard includes the design criteria for irrigation pipelines, the minimum installation requirements for plastic pipelines, and the specifications for the thermoplastic pipe to be used.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to the land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions Where Practice Applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water supplies and rates of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application method to be used.

Plastic pipelines installed under this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

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Design Criteria

Working Pressure

The minimum acceptable working pressure class shall be pipe having a rated operating head of 50 feet.

The pipeline shall be designed to meet all service requirements without an operating or static head at any point greater than the rated operating head of the pipe used at that point.

Capacity

The design capacity of the pipeline shall be based on whichever of the following criteria is the greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

Friction Losses

For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation using a roughness coefficient, c, equal to 150.

Outlets

Such appurtenances as are required to deliver water from the pipeline to an individual sprinkler or to a lateral line of sprinklers or surface pipe located on the ground surface shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the design flow to the individual sprinkler, surface lateral line of sprinklers, or surface pipe at the design operating pressure of the sprinkler or lateral line or surface pipe as the case may be.

Check Valves, Pressure Relief, Vacuum Release, and Air Release Devices

A check valve shall be installed between the pump discharge and the pipeline where detrimental backflow may occur.

A pressure relief valve shall be installed between the pump discharge and the pipeline when excessive pressures can be developed by operating with all valves closed. Also in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures could be developed, a surge chamber or a pressure relief valve shall be installed.

Pressure relief valves or surge chambers shall be installed at the end of the pipeline when needed to relieve surge at the end of the line. Pressure relief valves shall be no smaller than 1/4-inch normal size for each diameter inch of the pipeline, and shall be set to open at a pressure no greater than 5 p.s.i. above the pressure rating of the pipe.

Air release and vacuum release valves shall be placed at all summits in the pipeline, and also at the end of the line when needed to provide a positive means for air escape or air entrance.

Air release and vacuum release valve outlets of at least 1/2-inch nominal diameter shall be used in lines of 4-inch diameter or less, at least 1-inch outlets shall be used in lines of 5- to 8-inch diameter, and no smaller than 2-inch outlets shall be used in lines of 10- to 12-inch diameter.

Draining and Flushing Requirements

Provisions shall be made for draining the pipeline completely where a hazard is imposed by freezing temperatures, drainage is recommended by the manufacturer of the pipe, or drainage of the line is specified for the job for any reason. Where provisions for drainage are required, drainage outlets shall be located at all low places in the line and air inlets provided at summits to prevent the development of negative pressures. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be thus provided by gravity, provisions shall be made to empty the line by pumping.

Where provisions are needed to flush the line free of sediment, a suitable valve shall be installed at the distal end of the pipeline.

Solvent Welded Joints

Solvent welded joints shall be used only for PVC pipe of the following sizes and SDR's:

SDR	Sizes
51	5 in. and over
41	3 1/2 in. and over
32.5	3 in. and over
26	1 in. and over
21	3/4 in. and over
17	1/2 in. and over
13.5	1/2 in. and over

Materials
All materials shall meet the minimum requirements of this Standard under Engineering Specifications for Materials.

Minimum wall thickness shall be in accordance with pipe size and SDR as specified in Table 2, and in no case shall wall thickness be less than 0.06 inch.

Installation Requirements

Joints and Connections
All joints and connections shall be made so as to withstand the design maximum working pressure for the pipeline without leakage and shall leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements.

All fittings, such as couplings, reducers, bends, tees and crossings shall be made of material that is recommended for use with pipe and shall be installed in accordance with the recommendations of the pipe manufacturer.

Fittings made of steel or other metals subject to corrosion shall be adequately protected by wrapping with plastic tape or coating with high corrosion preventation qualities. Where plastic tape is used for corrosion protection, all surfaces to be wrapped shall be thoroughly cleaned and then coated with a primer compatible with the tape prior to wrapping.

Placement
The pipe shall be allowed to come to within a few degrees of the temperature that it will have after complete covering prior to any backfilling beyond shading. The pipeline shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic crossing, farming operations, freezing temperatures, or soil cracking. The minimum depth of cover shall be:

1. 18 inches for pipes 1/2 to 2 1/2 inches in diameter.

2. 24 inches for pipes over 2 1/2 and up to 4 inches in diameter.

3. 30 inches for pipes over 4 inches in diameter.

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. In such cases, the top width of the fill shall be no less than 10 feet and the side slopes no steeper than 6 horizontal to 1 vertical.

Where rock, hardpan, boulders or any other material which might damage the pipe are encountered, the trench shall be undercut a minimum of 4 inches below final grade. The material used to establish final grade shall be sand or fine graded stable soil.

Testing

The pipeline shall be thoroughly and completely tested for pressure strength and leakage before backfill operations are undertaken. The line shall be filled with water, taking care to bleed all entrapped air in the process. The pressure shall be slowly built up to the maximum design working pressure. The line shall be inspected in its entirety while the maximum working pressure is maintained. Where leaks are discovered they shall be promptly repaired and the line shall be retested. In some cases, it may be necessary to partially backfill the line before testing in order to hold the line in place. Where such is the case, the partial backfill shall be undertaken in accordance with the provisions specified under Backfilling, covering only the body of the pipe sections and leaving all joints and connections uncovered for inspection purposes.

It shall be demonstrated by testing that the pipeline will function properly at design capacity. At or below design capacity, there shall be no objectionable surge or water hammer. Objectionable flow conditions shall include continuing unsteady delivery of water, damage to the pipeline, or detrimental overflow from control valves.

Backfilling

The pipe shall be uniformly and continuously supported. Blocking or mounding shall not be used to bring the pipe to final grade.

The initial backfill shall be of selected fine grained material free from rocks or stones greater than one inch diameter and earth clods greater than approximately 2 inches in diameter. The initial fill shall be compacted firmly around and above the pipe to achieve a soil density equal to or exceeding the natural density of the undisturbed sidewalls of the trench. Care shall be taken to avoid deformation or displacement of the pipe during this phase of the operations.

When water packing is used, the pipeline first shall be filled with water. The initial backfill, before wetting, shall be of sufficient depth to insure complete coverage of the pipe after consolidation has taken place. Water packing is accomplished by adding water in such quantity as to thoroughly saturate the initial backfill without inundation. After saturation, the valves shall be closed and the pipeline shall remain full until final backfill is made. The wetted fill shall be allowed to dry until firm before final backfill is begun.

The remainder of the backfill shall be placed and spread in approximately uniform layers in such a manner as to completely fill the trench so that there will be no unfilled spaces in the backfill. Final backfill material shall be free of rocks or boulders greater than 3 inches in diameter and shall be added and compacted in a manner that will leave the fill at ground level after settlement has taken place. Rolling equipment shall not be used until a minimum of 18 inches of backfill material has been placed over the top of the pipe.

All special backfilling requirements of the manufacturer shall be strictly observed.

Marking

The pipe shall be adequately marked at intervals of not more than 5 feet. Markings shall include the following:

1. The nominal pipe size and the size system that applies (IPS or PIP); e.g., 4-IPS or 4-PIP.

2. The type of plastic pipe material in accordance with the designation code; e.g., PVC 1120.

3. The pressure rating in p.s.i. for water at 73.4 degrees F; e.g., 200 p.s.i.

4. The SCS or ASTM specification designation with which the pipe complies for IPS-sized pipe, or the designation PIP for pipe in this size system.

5. The manufacturer's name (or trademark) and code.

Basis of Acceptance

The acceptability of the pipeline shall be determined by inspections to check compliance with all the provisions of the standard with respect to the design of the line, the pipe and appurtenances used, and the minimum installation requirements.

Certification and Guarantee

All material shall conform to these minimum requirements and to the tests prescribed in the applicable Commercial Standard or ASTM specification.

The pipe shall be certified by a qualified testing laboratory for compliance with this Engineering Standard and Specifications Guide. Pipe that bears the seal of approval of the National Sanitation Foundation may be considered acceptable for this certification.

The Installing Contractor shall certify that his installation complies with the requirements of this specification. He shall furnish a written guarantee designed to protect the owner against defective workmanship and materials over a period of not less than 2 years.

Plans and Specifications

Plans and specifications for construction of High Pressure Underground Plastic Pipelines shall be in keeping with the Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

<u>Quality of Plastic Pipe</u>

The compound used in manufacturing the pipe shall meet the requirements of one of the following materials:

1. <u>Polyvinyl Chloride</u> (PVC) as specified in ASTM D 1784. Type I, Grade 1; Type I, Grade 2; Type II, Grade 1.

2. <u>Acrylonitrile-Butadiene-Styrene</u> (ABS) as specified in ASTM D 1788. Type I, Grade 2 and 3; Type II, Grade 1.

3. <u>Polyethylene</u> (PE) as specified in ASTM D 1248. Type II, Grade 3; Type III, Grade 2; Type III, Grade 3.

The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign inclusion or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density and other physical properties.

<u>Pipe Requirements</u>

The wall thickness shall be as determined by the standard dimension ratio (SDR) for a given allowable working pressure applicable to the type and grade of compound used in the manufacture of the pipe, as given in Table 1.

The pipe shall meet the following requirements:

1. For IPS[1]-sized pipe, all the applicable dimensional and quality requirements given in Table 2 and in ASTM specifications listed in Table 3.

2. For PIP[2]-sized pipe, the dimensional requirements given in Tables 4 and 5, and the requirements, with the exception of those concerned with outside diameters and wall thickness, of the applicable ASTM specifications listed in Table 3.

Tables 1 and 3 shall be considered revised to delete or to include additional plastic pipe materials as they are deleted or added to the applicable ASTM specifications listed in Table 3.

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[1]Outside diameter same as "Iron Pipe Sizes" (IPS)

[2]Plastic Irrigation Pipe

Fitting Requirements
Fittings for IPS-sized pipe shall meet all the dimensional and quality requirements given in the following applicable ASTM specifications:

ASTM D 2464 - PVC Fittings Threaded, Schedule 80
ASTM D 2465 - ABS Fittings Threaded, Schedule 80
ASTM D 2466 - PVC Fittings Socket, Schedule 40
ASTM D 2467 - PVC Fittings Socket, Schedule 80
ASTM D 2468 - ABS Fittings Socket, Schedule 40
ASTM D 2469 - ABS Fittings Socket, Schedule 80

Solvent
Solvent for solvent welded pipe joints shall conform to ASTM Specification D 2564.

IPS-OD Pipe
Requirements in addition to those in ASTM D 2241 for IPS-OD pipe shall be as follows:

1. Wall thicknesses and tolerances for SDR 51 PVC plastic pipe shall be as specified in Table 2.

2. Sustained pressure test conditions for water at 23 degrees C (73 degrees F) for SDR 51 PVC plastic pipe.

Standard Dimension Ratio	Pressure[1] required for test			
	PVC 1120, PVC 1220 and PVC 2120	PVC 2116	PVC 2112	PVC 2110
	p.s.i.	p.s.i.	p.s.i.	p.s.i.
SDR 51	170	135	115	90

[1]The design stress levels used to derive these test pressures are:

PVC 1120 - 4200 p.s.i.   PVC 2116 - 3360 p.s.i.
PVC 1220 - 4200 p.s.i.   PVC 2112 - 2800 p.s.i.
PVC 2120 - 4200 p.s.i.   PVC 2110 - 2300 p.s.i.

3. Burst pressure requirements for water at 23 degrees C (73 degrees F) for SDR 51 PVC plastic pipe.

Standard Dimension Ratio	Minimum burst pressures[1]	
	PVC 1120 PVC 1220 PVC 2120	PVC 2116 PVC 2112 PVC 2110
	p.s.i.	p.s.i.
SDR 51	260	200

[1]The design stress levels used to derive these test pressures are:

PVC 1120 - 6400 p.s.i. PVC 2116 - 5000 p.s.i.
PVC 1220 - 6400 p.s.i. PVC 2112 - 5000 p.s.i.
PVC 2120 - 6400 p.s.i. PVC 2110 - 5000 p.s.i.

Some minor adjustments have been made to keep the test pressures uniform to simplify testing.

Table 1

Water Pressure Rating in p.s.i.

By types, grades, and standard dimension ratios of non-threaded pipes.

	PVC Materials				ABS Materials				PE Materials		
SDR[1]	PVC 1120 1220 2120	PVC 2116	PVC 2112	PVC 2110	ABS 1316	ABS 2112	ABS 1210	ABS 1208	PE 3206 3306	PE 2306	PE 2305
7.0											125
9.0									125	125	100
11.5									100	100	80
13.5	315	250	200	160	250	200	160	125	80	80	63
17.0	250	200	160	125	200	160	125	100	63	63	50
21.0	200	160	125	100	160	125	100	80	50	50	
26.0	160	125	100	80	125	100	80	63			
32.5	125	100	80	63	100	80	63	50			
41.0	100	80	63	50	80	63	50				
51.0	80	63	50		63	50					

[1]SDR = Standard dimension ratio

$$SDR = \frac{\text{Average outside diameter (inches)}}{\text{Minimum wall thickness (inches)}} \text{ for PVC and ABS pipe}$$

$$SDR = \frac{\text{Average inside diameter (inches)}}{\text{Minimum wall thickness (inches)}} \text{ for PE pipe}$$

Table 2

WALL THICKNESS AND TOLERANCES - PVC PIPE (INCHES)

Nominal Size, in.	SDR 51		SDR 41		SDR 32.5		SDR 26	
	Min.	Tol.	Min.	Tol.	Min.	Tol.	Min.	Tol.
1							(0.060)	+0.020
1 1/4							0.064	+0.020
1 1/2					(0.060)	+0.020	0.073	+0.020
2			0.060	+0.020	0.073	+0.020	0.091	+0.020
2 1/2	0.060	+0.020	0.071	+0.020	0.089	+0.020	0.110	+0.020
3	0.069	+0.020	0.086	+0.020	0.108	+0.020	0.135	+0.020
3 1/2	0.079	+0.020	0.098	+0.020	0.123	+0.020	0.154	+0.020
4	0.089	+0.020	0.110	+0.020	0.138	+0.020	0.173	+0.021
5	0.109	+0.020	0.136	+0.020	0.171	+0.021	0.214	+0.027
6	0.130	+0.020	0.162	+0.020	0.204	+0.024	0.255	+0.031
8	0.169	+0.020	0.210	+0.025	0.265	+0.032	0.332	+0.040
10	0.211	+0.025	0.262	+0.031	0.331	+0.040	0.413	+0.050
12	0.250	+0.030	0.311	+0.037	0.392	+0.047	0.490	+0.059

Nominal Size, in.	SDR 21		SDR 17		SDR 13.5	
	Min.	Tol.	Min.	Tol.	Min.	Tol.
1/2			(0.060)	+0.020	0.062	+0.020
3/4	(0.060)	+0.020	0.062	+0.020	0.078	+0.020
1	0.063	+0.020	0.077	+0.020	0.097	+0.020
1 1/4	0.079	+0.020	0.098	+0.020	0.123	+0.020
1 1/2	0.090	+0.020	0.112	+0.020	0.141	+0.020
2	0.113	+0.020	0.140	+0.020	0.176	+0.021
2 1/2	0.137	+0.020	0.169	+0.020	0.213	+0.026
3	0.167	+0.020	0.206	+0.025	0.259	+0.031
3 1/2	0.190	+0.023	0.235	+0.028	0.296	+0.036
4	0.214	+0.026	0.265	+0.032	0.333	+0.040
5	0.265	+0.032	0.327	+0.039	0.412	+0.049
6	0.316	+0.038	0.390	+0.047	0.491	+0.059
8	0.410	+0.049	0.508	+0.061		
10	0.511	+0.061	0.632	+0.076		
12	0.606	+0.073	0.750	+0.090		

Notes

Solvent welded joints may be used only for sizes and SDR below the heavy line.

For sizes in parentheses, furnish either 0.060 wall thicknesses or same size of next smaller SDR.

Table 3

Design Stress and Designation - Plastic Pipe

Compound	Type	Grade	Hydrostatic Design Stress	Designation	IPS - sized pipe ASTM No.
PVC	I	1	2000 p.s.i.	PVC 1120	D 2241
PVC	I	2	2000 p.s.i.	PVC 1220	D 2241
PVC	II	1	1000 p.s.i.	PVC 2110	D 2241
PVC	II	1	1250 p.s.i.	PVC 2112	D 2241
PVC	II	1	1600 p.s.i.	PVC 2116	D 2241
PVC	II	1	2000 p.s.i.	PVC 2120	D 2241
ABS	I	2	1000 p.s.i.	ABS 1210	D 2282
ABS	I	2	800 p.s.i.	ABS 1208	D 2282
ABS	I	3	1600 p.s.i.	ABS 1316	D 2282
ABS	II	1	1250 p.s.i.	ABS 2112	D 2282
PE	II	3	500 p.s.i.	PE 2305	D 2239
PE	II	3	630 p.s.i.	PE 2306	D 2239
PE	III	2	630 p.s.i.	PE 3206	D 2239
PE	III	3	630 p.s.i.	PE 3306	D 2239

Table 4

OUTSIDE DIAMETERS OF PLASTIC IRRIGATION PIPE (PIP)

For ABS and PVC Pipe

PIP Size	Outside Diameter	Tolerance		
		For Average Measurements	For maximum and minimum	
			SDR 51, 41, 32.5 26, and 21	SDR 17 and 13.5
inches	inches	inches	inches	inches
4	4.130	±0.009	±0.050	±0.015
6	6.140	±0.011	±0.050	±0.030
8	8.160	±0.015	±0.070	±0.042
10	10.200	±0.015	±0.075	±0.050
12	12.240	±0.015	±0.075	±0.060

Table 5

WALL THICKNESS[1] OF PLASTIC IRRIGATION PIPE (PIP)

PIP Size inches	SDR 51 Minimum inches	SDR 51 Tolerance inches	SDR 41 Minimum inches	SDR 41 Tolerance inches	SDR 32.5 Minimum inches	SDR 32.5 Tolerance inches
4	--	--	0.101	+0.020	0.127	+0.020
6	0.120	+0.020	0.150	+0.020	0.189	+0.023
8	0.160	+0.020	0.199	+0.024	0.251	+0.031
10	0.200	+0.024	0.249	+0.030	0.314	+0.038
12	0.240	+0.029	0.299	+0.036	0.377	+0.045

PIP Size inches	SDR 26 Min. inches	SDR 26 Tol. inches	SDR 21 Min. inches	SDR 21 Tol. inches	SDR 17 Min. inches	SDR 17 Tol. inches	SDR 13.5 Min. inches	SDR 13.5 Tol. inches
4	0.159	+0.020	0.197	+0.024	0.243	+0.029	0.306	+0.037
6	0.236	+0.028	0.292	+0.035	0.361	+0.043	0.455	+0.054
8	0.314	+0.038	0.389	+0.047	0.480	+0.058	0.604	+0.072
10	0.392	+0.047	0.486	+0.058	0.600	+0.072	0.756	+0.091
12	0.471	+0.056	0.583	+0.070	0.720	+0.086	0.907	+0.109

[1] The minimum is the least wall thickness of the pipe at any cross section. All tolerances are on the plus side of the minimum requirement.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
Low Head Underground Plastic

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies to underground thermoplastic pipelines from 4 to 15 inches in diameter that are subject to internal working pressures up to 50 feet head of water.

The standard includes the design criteria for these irrigation pipelines, the minimum installation requirements, and the specifications for the thermoplastic pipe to be used. It includes pipelines with stands and vents open to the atmosphere, and pipelines not open to the atmosphere but provided with pressure relief valves.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to the land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions Where Practice Applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water supplies and rates of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Plastic pipelines installed under this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

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Design Criteria

A. Working Pressure

The pipeline shall be designed in such a manner that the maximum static or working head in the line, including freeboard for pipelines open to the atmosphere, does not exceed 50 feet head of water.

B. Friction Losses

For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation using a roughness coefficient, c, equal to 150.

C. Capacity

The design capacity of the pipeline shall be based on whichever of the following criteria is the greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

D. Outlets

Appurtenances to deliver water from the pipe system to the land, to a ditch, or to any surface pipe system shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow (1) to the hydraulic grade line of a pipe or ditch, or (2) to a point at least 6 inches above the field surface.

E. Joints

Any type of joining system that produces a watertight joint having adequate strength for satisfactory service may be used, except that the sleeves or bell ends or plastic fittings shall be made from the same type of plastic as the pipe.

There shall be a minimum of 4 inches of overlap between the joint sleeve and the pipe or fittings for clamp type joints. Solvent welded joints shall be made with fittings or bells with tapered type sockets. The minimum overlap for solvent cemented bell end joints shall be 40 percent of the inside diameter of the pipe or 3 inches, whichever is greater.

Manufacturers' recommendations for joining pipe shall be used where not in conflict with requirements of this section on Joints.

F. Draining and Flushing Requirements

Provisions shall be made for draining the pipeline completely where (1) a hazard is imposed by freezing temperatures, (2) drainage is recommended by the manufacturer of the pipe, or (3) drainage of the line is specified for the job for any reason. Where provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of low elevation. If drainage cannot be thus provided by gravity, provisions shall be made to empty the line by pumping.

Where provision is needed to flush the line free of sediment, a suitable valve shall be installed at the distal end of the pipeline.

G. Design of Pipelines Open to the Atmosphere

General - Stands shall be used wherever water enters the pipeline to avoid entrapment of air, to prevent surge-pressures, to avoid collapse due to vacuum failure, and to prevent pressure from exceeding the design working stress of the pipe. All stands shall be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. Stands shall be designed:

1. To allow at least 1 foot of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor the design working head plus freeboard shall exceed the working head class of the pipe.

2. With the top of each stand at least 4 feet above the ground surface except for surface gravity inlets which shall be equipped with trash racks and covers.

3. With downward water velocities in stands not in excess of 2 feet per second. In no case shall the inside diameter of the stand be less than the inside diameter of the pipeline.

Pump Stands - When the water velocity of an inlet pipe exceeds 3 times the velocity of the outlet, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.

The cross-sectional area of stands may be reduced above a point 1 foot above the top of the upper inlet but in no case shall the reduced cross section be such that it would produce an average velocity of more than 10 feet per second if the entire flow were discharging through it.

Pump stands shall be one of the following types:

1. Steel cylinder stands.

2. Concrete box stands with vertical sides, suitably reinforced.

3. Non-tapered stands of concrete pipe, suitably reinforced.

4. Non-tapered concrete pipe stands, capped and having a vent pipe of the height required to take care of hydraulic gradient plus freeboard.

Check valves shall be installed in the pump discharge line where detrimental backflow from the pipeline can occur.

Construction shall be such as to insure that the vibration from the pump discharge pipe is not carried to the stand.

<u>Sand Traps</u> - Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 inches and shall be constructed so that the bottom is at least 24 inches below the invert of the outlet pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 feet per second. Suitable provisions for cleaning sand traps shall be provided.

<u>Gate Stands and Float Valve Stands</u> - Gate stands shall be of sufficient dimensions to accommodate the gate or gates and shall be large enough to make the gates accessible for repair. Float valve stands shall be large enough to provide accessibility for maintenance and to dampen surge.

<u>Vent Requirements</u> - Vents shall be designed into the system to provide for the removal of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 foot above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the working head class of the pipe.

2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least 1 pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 inches in diameter.

3. Be located:

    a. At the downstream end of each lateral.

    b. At summits in the line.

c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees.

d. Immediately below any stand if the downward velocity in the stand exceeds 1 foot per second.

Air-Vacuum Release Valves - An air-vacuum release valve may be used in lieu of an open vent, but either a vent or an air-vacuum release valve shall be provided at each of the locations in item 3 of Vent Requirements, above. Air-vacuum release valve outlets shall have a 2-inch nominal minimum diameter. Two-inch outlets shall be used for lines of 6-inch diameter or less, 3-inch outlets for lines of 7-inch to 10-inch diameter, and 4-inch outlets for lines of 12-inch diameter.

An air-vacuum release valve shall not replace the open stand required under "General."

H. Design of Pipelines Not Open to the Atmosphere

General - Pressure relief valves may be used on low-head plastic pipelines as an alternative to design with stands open to the atmosphere. A pressure relief valve shall serve the pressure relief function of the open stand or vent for which it is an alternative.

Pressure relief valves do not function as air release valves and shall not be used as substitutes for such valves where release of entrapped air is required.

The flow capacity of pressure release valves shall be the pipeline design flow rate with a pipeline pressure no greater than 50 percent above the permissible working head for the pipe.

Marking and Setting - Pressure relief valves shall be marked with the pressure at which the valve starts to open. Adjustable pressure relief valves shall be sealed or otherwise altered to prevent changing of the adjustment from that marked on the valve.

Other Design - Air-vacuum release valves shall be used at each location specified in Vent Requirements, Pipelines Open to the Atmosphere. The size of outlet for air-vacuum release valves shall be as specified in Air-Vacuum Release Valves, Pipelines Open to the Atmosphere.

Design of check valves, vibration control, gate stands, and sand traps shall be as specified for Pipelines Open to the Atmosphere.

I. Materials

All materials shall meet or exceed the minimum requirements of this Standard under Engineering Specifications for Materials.

Installation Requirements

Joints and Connections

All joints and connections shall be made so as to withstand the design maximum working pressure for the pipeline without leakage and shall leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements.

All fittings, such as couplings, reducers, bends, tees and crossings shall be made of the material recommended for use with the pipe and shall be installed in accordance with the recommendations of the pipe manufacturer.

Fittings made of steel or other metals subject to corrosion shall be adequately protected by wrapping with plastic tape or coating with high corrosion prevention qualities. Where plastic tape is used for corrosion protection, all surfaces to be wrapped shall be thoroughly cleaned and then coated with a primer compatible with the tape prior to wrapping.

Installation Requirements

The pipeline shall be installed at sufficient depth below the ground surface to provide protection from hazards imposed by traffic crossing, farming operations, freezing temperatures, or soil cracking. Thirty inches minimum cover shall be provided except in soils subject to deep cracking where the cover shall be a minimum of 36 inches. The maximum depth of cover for all pipe sizes shall be 4 feet.

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. In such cases the top width of the fill shall be no less than 10 feet and the side slopes no steeper than 6 horizontal to 1 vertical.

The width of the trench at any point below the top of the pipe shall be no wider than is necessary to lay, join, and backfill the pipe, and in no event shall the trench be more than 24 inches wider than the nominal diameter of the pipe.

Where rock, hardpan, boulders or any other material which might damage the pipe are encountered, the trench shall be cut at least 4 inches below final grade. The material used to establish final grade shall be sand or fine graded stable soil.

Testing

The pipeline shall be thoroughly and completely tested for pressure strength and leakage before backfill operations are undertaken. The line shall be filled with water taking care to bleed all entrapped air in the process. The pressure shall be slowly built up to the maximum design working head of the system. The line shall be inspected in its entirety while the maximum working head of the

system is maintained. Where leaks are discovered they shall be promptly repaired and the line shall be re-tested. All leaks shall be repaired before proceeding with backfill. In some cases, it may be necessary to partially backfill the line before testing in order to hold the line in place. Where such is the case, the partial backfill shall be undertaken in accordance with the provisions specified under Backfilling, covering only the body of the pipe sections and leaving all joints and connections uncovered for inspection purposes.

It shall be demonstrated by testing that the pipeline will function properly at system design capacity. At or below design capacity, there shall be no objectionable surge or water hammer. Objectionable flow conditions shall include continuing unsteady delivery of water, damage to the pipeline, or detrimental overflow from vents or stands.

Backfilling

The pipeline and stand pipes shall be filled and maintained at the system design head pressures during the complete backfilling operation. The pipe shall be uniformly and continuously supported. Blocking or mounding shall not be used to bring the pipe to final grade.

The initial backfill shall be of selected fine-grained material free from rocks or stones greater than one inch diameter and earth clods greater than about 2 inch diameter. Water packing shall be used whenever possible. In instances where water packing is not possible, the initial fill shall be compacted firmly around and above the pipe to achieve a soil density equal to or exceeding the natural density of the undisturbed sidewalls of the trench. Care shall be taken to avoid deformation or displacement of the pipe during this phase of the operation.

When water packing is used, the pipeline shall be filled with water. The initial backfill, before wetting, shall be of sufficient depth to insure complete coverage of the pipe after consolidation has taken place. Water packing is accomplished by adding water in such quantity as to thoroughly saturate the initial backfill without inundation.

After saturation, the valves shall be closed and the pipeline shall remain full until final backfill is made. The wetted fill shall be allowed to dry until firm enough to walk on before final backfill is begun.

The remainder of the backfill shall be placed and spread in approximately uniform layers in such a manner as to completely fill the trench so that there will be no unfilled spaces in the backfill. Final backfill material shall be free of rocks or boulders greater

than 3 inches in diameter and shall be added and compacted in a manner that will leave the fill at ground level after settlement has taken place. Rolling equipment shall not be used until a minimum of 30 inches of backfill material has been placed over the top of the pipe.

Marking

The pipe shall be marked as a minimum, at not more than 5-foot intervals, with the following:

1. Type and grade of plastic material.
2. Nominal pipe size.
3. 50 ft. head.
4. Manufacturers designation.

Basis of Acceptance

The acceptability of the pipeline shall be determined by inspections to check conformance with all the provisions of this standard with respect to the design of the line, the pipe and appurtenances used, and the minimum installation requirements.

Certification and Guarantee

The pipe shall be certified by the manufacturer for compliance with this SCS Engineering Standard.

The installing contractor shall certify that his installation complies with the requirements of this standard. He shall furnish a guarantee of workmanship and installation to cover a period of not less than 2 years, and shall name the source of the plastic pipe and the accessories used.

Plans and Specifications

Plans and specifications for construction of Low Head Underground Plastic Pipelines shall be in keeping with the Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Plastic Pipe

The materials used to make the pipe shall meet all the requirements of the following applicable material specifications:

Polyvinyl Chloride Plastic (PVC) - ASTM D 1784. Type 1 Grade 1; Type I, Grade 2; and Type II, Grade 1.

Polyethylene Plastic (PE) - ASTM D 1248. Type III, Grade 2, and Type III, Grade 3.

Acrylonitrile-Butadiene-Styrene Plastic (ABS) - ASTM D 1788. Type I, Grade 1, and Type I, Grade 2.

The pipe shall meet the applicable dimensional requirements in Table 1 following, on the basis of the material selected.

In addition to the above, PVC pipe shall meet the requirements of Sections 3(e), 5(a), 5(e), 5(f), 6(a), 6(b), 6(c), 6(g), and 6(h) of ASTM D 2241 where not in conflict with any of the requirements of this low head irrigation pipeline standard. The dimensions and tolerances shall be measured in accordance with the procedures given in ASTM D 2122.

In addition to the above, PE pipe shall meet the requirements of Sections 3(a), 5(a), 5(b), 5(d), 5(e), 6(a), 6(b), 6(c), 6(d), 6(e), and 6(f) of ASTM D 2239 where not in conflict with any of the requirements of this low head irrigation pipeline standard.

In addition to the above, ABS pipe shall meet the requirements of Sections 3(e), 5(a), 5(e), 6(a), 6(b), 6(c), and 6(g) of ASTM D 2282 where not in conflict with any of the requirements of this low head irrigation pipeline standard. The dimensions and tolerances shall be measured in accordance with procedures given in ASTM D 2122.

Table 1

DIMENSIONS OF LOW HEAD PLASTIC IRRIGATION PIPE

LH - PIP[1/] Nominal Size	Inside Diameter		Wall Thickness, Minimum	
	Minimum	Tolerance	ABS and PVC Materials	PE Materials
inch	inch	inch	inch	inch
4	4.000	±0.020	0.065	0.085
6	6.000	±0.025	0.070	0.095
8	8.000	±0.040	0.080	0.120
10	10.000	±0.040	0.100	0.135
12	12.000	±0.040	0.120	0.155
15	15.000	±0.040	0.150	0.200

[1/] Low Head - Plastic Irrigation Pipe

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
Steel

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard covers the design and installation of buried steel irrigation pipelines and steel irrigation pipelines permanently installed on above-the-ground supports. It is restricted to pipelines not greater than 48 inches in diameter, and does not apply to short pipes used in structures such as siphons, outlets from canals, and culverts under roadways.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions Where Practice Applies

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All lands served by the pipeline shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Design Criteria

Working Pressure

The pipeline shall be designed to meet all service requirements without the use of a working pressure which will produce tensile stresses in the pipe greater than a design stress equal to 50 percent of yield-point stress. Design stresses for commonly used steel and steel pipe classes are shown in column 2 of Table 1.

Table 1

Specification and Grade of Steel	Design Stress 50% Yield Point - p.s.i.
ASTM A 283	
Grade B	13,500
Grade C	15,000
Grade D	16,500
ASTM A 570	
Grade A	12,500
Grade B	15,000
Grade C	16,500
Grade D	20,000
Grade E	21,000
AWWA C 202	
Furnace butt weld	12,500
Grade A	15,000
Grade B	17,500
Grade X42	21,000

In computing tensile stresses in steel pipe, the following items must be considered:

1. The pressure to be delivered at the end of the pipeline.

2. The friction head loss.

3. The elevation differential between the outlet and the inlet of the pipe.

4. Any pressure due to water hammer or surge which may be created by the closure of a valve in the pipeline.

Flow Capacity

The design capacity shall be based upon whichever of the following is the greater:

1. Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown.

2. Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

Minimum Wall Thickness

Minimum pipe wall thickness shall be as follows:

4" through 12" nominal diameter - 14 guage less 12.5%

14" through 18" nominal diameter - 12 guage less 12.5%

20" through 24" nominal diameter - 10 guage less 12.5%

26" through 36" nominal diameter - 3/16 inch less 12.5%

38" through 48" nominal diameter - 1/4 inch less 12.5%

Friction Loss

For design purposes the pipeline friction loss shall be based on that computed with Manning's formula with "n" equal to no less than 0.012 for unlined pipe and no less than 0.010 for lined pipe.

Check Valves, Pressure Relief, Vacuum Release, and Air Release Valves

Where detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure relief valve shall be installed at the pump location when excessive pressure can be developed by operating with all valves closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures could be developed, a surge chamber or pressure relief valve shall be installed close to the check valve on the side away from the pump.

Pressure relief valves shall be no smaller than 1/4-inch nominal size for each diameter inch of the pipeline, and shall be set at a maximum of 5 p.s.i. above the safe working pressure of the pipeline.

A pressure relief valve or surge chamber shall be installed at the end of the pipeline when needed to relieve surge.

Air release and vacuum release valves or combination air release - vacuum release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve when needed to provide a positive means of air entrance or escape.

Air release and vacuum release valve outlets shall be at least 1/2-inch nominal diameter when specified for lines of 4-inch diameter or less, at least 1-inch outlets for lines of 5- to 8-inch diameter, at least 2-inch outlets for lines of 10- to 16-inch diameter, at least 4-inch outlets for lines of 18- to 28-inch diameter, at least 6-inch outlets for lines of 30- to 36-inch diameter, and at least 8-inch outlets for lines of 38- to 48-inch diameter.

For pipelines larger than 16-inch diameter, 2-inch air release valves may be used in place of the sizes indicated above if they are supplemented with vacuum release valves that will provide vacuum release capacity equal to the sizes shown.

Draining and Flushing Requirements

Provisions shall be made for draining the pipeline completely where a hazard is imposed by freezing temperatures or drainage is specified for the job.

Where provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping.

Outlets

Appurtenances to deliver water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known as outlets. Outlets shall have capacity to deliver the required flow:

1. To a point at least six inches above the field surface.

2. To the hydraulic gradeline of a pipe or ditch.

3. To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line, as the case may be.

Pipe Supports

Irrigation pipelines place above ground shall be supported by suitably built concrete or timber saddles shaped to support the pipe throughout the arc of contact, which shall be not less than 90° nor more than 120° as measured at the central angle of the pipe. Where needed to prevent overstressing, ring girder type supports shall be used. Support spacing shall be such that neither the maximum beam stresses in the pipe span or the maximum stress at the saddle will result in stresses exceeding the design stress values.

Anchors, Thrustblocks, and Expansion Joints

For above-ground pipelines with welded joints, anchor blocks and expansion joints shall be installed at spacings that will limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum length of pipeline without expansion joint shall be 500 feet. Above-ground pipelines with rubber gasket type joints shall have the movement of each pipe length restrained by steel holddown straps at the pipe supports or by anchor blocks in lieu of normal pipe supports.

Anchor blocks usually will not be required on buried pipelines. Expansion joints shall be installed as needed to limit stresses in the pipeline to the design values.

Thrust blocks are required on both buried and above ground pipelines at all points of abrupt changes in grade, horizontal alignment, or reduction in size. The blocks must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure as well as forces due to expansion and contraction.

Joints and Connections

All connections shall be designed and constructed to withstand the working pressure of the line without leakage and leave the inside of the pipeline free of any abstruction that would reduce the line capacity below design requirements. On sloping lines, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks. Where cathodic protection is required, high resistance joints shall be bridged to insure continuous flow of current.

A dielectric connection shall be placed between the pump and the pipeline and between pipes with different coatings.

Corrosion Protection

Pipe Interior. - Interior protective coatings shall be provided where the pH of the water conveyed is 6.5 or lower. Cement mortar coatings may be used when the water to be conveyed has a pH of 5.5 or higher and a sulfate content of 150 ppm or less.

Pipe Exterior - Underground Lines. All pipe exteriors must be provided with full protection against corrosion. To meet protection requirements, all pipe must be coated and must be provided with supplementary cathodic protection as specified in item 2 below:

1. Criteria for Determining Class of Coating
   Class A protection coating shall be provided when the soil resistivity survey shows either (1) twenty percent or more of the total surface area of the pipeline will be in soil which has a resistivity of 1500 ohm-cm or less; or (2) ten percent or more of the total surface area of the pipeline will be in soil which has a resistivity of 750 ohm-cm or less. Class B coating shall be provided for all other soil conditions.

2. Cathodic Protection Requirements
   Supplementary cathodic protection shall be provided when the soil resistivity survey shows any portion of the pipeline will be in soil whose resistivity is less than 10000 ohm-cm unless galvanized pipe is used. Pipe to soil potential shall be not less than 0.85 volts negative, referred to a copper/copper-sulfate reference electrode, with the cathodic

protection installed. The initial anode installation shall be sufficient to provide protection for a minimum of 15 years.

Cathodic protection shall be provided for galvanized pipe when the soil resistivity survey shows any portion of the galvanized pipe will be in soil whose resistivity is less than 4000 ohm-cm. Galvanized pipe requiring cathodic protection shall have class B coating.

The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below:

a. The total cathode current required may be estimated from the formula:

$$I_t = C\left[\frac{A_1}{R_{e1}} + \frac{A_2}{R_{e2}} + \cdots \cdots \frac{A_n}{R_{en}}\right]$$

Where: I_t = total current requirement in ma

A = surface area of pipe in square feet

R_e = soil resistivity in ohm-cm

C = a constant for a given pipe coating

For design purposes this constant shall be considered to be not less than 32 for Class A coatings and not less than 60 for Class B coatings.

b. The kind of galvanic anode to be used is dependent upon the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

(a) less than 2000 ohm-cm use zinc anodes;

(b) between 2000 and 3000 ohm-cm use either zinc or magnesium anodes;

(c) between 3000 and 10000 ohm-cm use magnesium anodes.

Anodes shall not be required on pipelines where soil resistivity is greater than 10000 ohm-cm.

c. The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

Thus: $N = I_t/I_m$ and $I_m = k/R$

Where: N = number of anodes needed

I_t = total current requirement in ma

I_m = maximum anode current output in ma

k = constant for a given anode

R = soil resistivity of the anode bed in ohm-cm

d. The expected life of an anode, based on the use of 17# per ampere year for magnesium and 26# per ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

Magnesium $Y = 47W/I_o$

Zinc $Y = 31W/I_o$

Where: Y - expected life in years

W = weight of anode in pounds

I_o = design anode current in ma = I_m unless resistors are used in the anode circuit to reduce current output

Note: If resistors are used to reduce anode current output in order to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than the maximum output, I_m.

3. Soil Resistivity Determinations

Preliminary soil resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed may be made before the trench is excavated. For this purpose, field resistivity measurements shall be made, or samples for laboratory analysis shall be taken, at least every 400 feet along the proposed pipeline and at points where there is a visible change in soil characteristics. Wherever a reading differs markedly from a preceding one, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling station, the lowest depth to be the strata in which the pipe will be laid. The lowest value

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of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil resistivity survey shall be made as a basis for final design of the coating and the required cathodic protection. At this time resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 feet. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. Where design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

Pipe Exterior - Above Ground Lines. - All pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coatings.

Materials

All materials shall meet or exceed the minimum requirements of this Standard including Engineering Specifications for Materials.

Installation Requirements

Placement: Buried Pipelines

Pipe shall be laid to the lines and grades as shown on the drawings and/or as staked in the field, and shall be placed deep enough below the land surface to protect it from the hazards imposed by traffic crossings, farm operations, freezing temperatures or soil cracking. Two feet minimum cover shall be provided except in soils subject to deep cracking where the cover shall be a minimum of three feet. Where necessary to place the pipe at lesser depth, adequate protection shall be provided by means of the placement of extra fill over the pipeline, by the use of a fence or other surface barrier, or by the use of extra heavy gauge pipe.

Where trenches are excavated in soils containing rock or other hard material that might damage pipe or coating material, the trenches shall be excavated slightly deeper than required and then filled to grade with sand or fine earth.

Coated pipe shall be handled so as to prevent abrasion of the coating during transportation and handling and during placement and backfilling of the pipeline. No pipe shall be dropped from cars or trucks or allowed to roll down skids without proper restraining ropes. Each section of pipe shall be delivered in the field as near as practicable to the place where it is to be installed. When stockpiled it shall be neatly piled and blocked with strips between tiers.

Where it is necessary to move the pipe longitudinally along the trench, it shall be done in such a manner as not to injure the pipe or coating. Pipe shall not be rolled or dragged on the ground. If the pipe is supported, as for welding, supports shall be of sufficient width and number, and padded if necessary, to prevent damage to the coating.

Joints and Connections

Special field joints shall be installed in strict accordance with the manufacturer's recommendations. On buried pipelines, high resistance joints between pipe lengths shall be electrically bridged with a welded, brazed, or soldered copper wire not smaller than 4/0 gauge in size. If coated pipe is field welded, special care shall be taken to avoid burning the protective coating. After the joints have been welded, they shall be covered with a coating equal in quality to that specified for the pipe. Dielectric connections shall be placed as specified on the drawings.

Placement: Above-Ground Pipelines

Concrete, timber or other pipe supports and anchor and thrust blocks shall be constructed at the locations and to the dimensions as shown on the drawings and/or as staked in the field. Saddles shall be shaped to firmly support the pipe throughout the full arc of contact. At least two layers of felt strips shall be placed between the pipe and its support. The felt shall cover the entire area of contact between the pipe and the saddle. A graphite lubricant shall be placed between the felt strips before the pipe is placed in the saddle.

Paint

Unless otherwise specified, all above-ground pipelines shall be painted as follows:

1. All grease and oil shall be removed from the pipe surface by steam cleaning or by solvent cleaning and all dirt, surface rust, and loose scale shall be removed by means of wire brushing, flame cleaning, use of rotary abrading tools or by light sand-blasting.

2. To the cleaned pipe there shall be applied one priming coat of red lead base paint conforming to the requirements of Federal Specification TT-P-86e, Type I, II or III, or one priming coat of synthetic primer conforming to the requirements of Federal Specification TT-P-636c(1).

3. The painting shall be completed by the application of two coats of aluminum paint. The aluminum paint shall be prepared by mixing aluminum paste conforming to Federal Specification TT-P-320b(1), Type II, Class B with mixing varnish conforming to the requirements of Federal Specification TT-V-81d, Type II, Class B, at the rate of two

pounds of aluminum paste per gallon of varnish. The paint shall be mixed at the time of use.

Coatings

Coating material and application procedures shall be as specified in Engineering Specifications for Materials by class of coating.

Cathodic Protection

Buried steel pipelines will be protected with sacrificial galvanic anodes where specified to supplement the protection provided by the pipe coating. The anodes shall be of the kind and number as specified for the job and/or as shown on the drawings. Anode materials shall be as specified in Engineering Specifications for Materials.

Anode Installation. - Anodes shall be placed as shown on the drawings. When placed horizontally, they shall be at or below the bottom elevation of the pipeline. Vertically placed anodes shall have a minimum distance to 3 feet between the ground surface and the top of the anode. Anodes shall not be placed in fill areas, and magnesium anodes must be placed a minimum distance of 10 feet from the pipeline.

Anodes shall be bedded in moist fine clay, clay loam, silt, or silt loam materials. In sandy and gravelly areas fine material must be imported for bedding and for covering the anodes to a depth of 6 inches. The packaged anodes and the fine textured soil used for bedding and backfill shall be thoroughly wetted.

Attachment of Anode to Pipe. - The lead wire from the anode, or the header wire for multiple anode installations, shall be attached to the pipeline by cadwelding, thermowelding, or other process of equal ability. The area of damaged pipe coating and the weld shall then be covered with a coating equal in quality to the specified original pipe coating.

Anode Testing Stations. - Testing station facilities shall be located and installed as specified for the job and/or as shown on the drawings. Wires at testing stations shall be attached to the pipe as specified above for anode lead wires.

Testing

Underground steel pipelines shall be tested before backfill has been placed over the field joints. Above-ground steel pipelines may be tested at any time after they are ready for operation.

The pipeline shall be filled with water, taking care to bleed air and prevent water hammer. When the line is full, all valves shall be closed and the line shall be brought up to full design working pressure. All joints shall then be carefully inspected for leakage and any visible leaks shall be repaired.

It shall be demonstrated by testing that all valves, vents, surge chambers and other appurtenances function properly when the pipeline is operated at design capacity. Objectionable surge, water hammer, unsteady delivery of water, damage to the pipeline, and detrimental discharge from control valves are evidence of malfunction.

Plans and Specifications

Plans and specifications for Steel Irrigation Pipelines shall be in keeping with this Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Pipe
Pipe shall equal or exceed the specifications of the American Water Works Association for "Fabricated Electrically Welded Steel Water Pipe," Designation AWWA C 201, or "Mill-Type Steel Water Pipe," Designation AWWA C 202.

Appurtenances
Standard fittings for the pipe shall be used. Elbows, tees, crosses, reducers, gate valves, check valves, air and vacuum release valves, pressure relief valves, and pressure regulators shall be of the size and type of material specified and/or shown on the drawings.

Interior Coatings
When an interior coating is specified, the coating shall meet the requirements of one of the following:

Coal-Tar Enamel. - The interior of the pipe shall receive a coat of coal-tar primer followed by a hot coat of coal-tar enamel applied either by manual or mechanical means. All material and application shall be in accordance with applicable parts of American Water Works Association Specification C 203 pertaining to interior coatings.

Cement Mortar. - Materials and workmanship shall be equal to American Water Works Association Specification C 205.

Epoxy Resin. - Epoxy resin interior coatings shall meet the requirements given in a following section of these specifications for epoxy resin exterior coatings.

Exterior Coatings
Exterior coatings shall be Class A, Class B, or Paint as specified for the job.

Class A Coatings. - When a Class A coating is required, the coating shall meet the requirements of one of the following:

1. Coal-Tar Enamel - The outside of the pipe shall receive a coat of coal-tar primer followed by a hot coat of coal-tar enamel into which shall be bonded an asbestos felt wrapper and finished with a Kraft paper or one coat of water-resistant whitewash. All materials and application shall be in accordance with American Water Works Association Specification C 203.

2. Epoxy Resin - Epoxy resin coatings shall have physical characteristics and be applied as follows:

    a. Pipe shall be cleaned of all contaminants such as lacquer, wax, coal-tar, asphalt, oil or grease.

b. Pipe shall be shot blasted to white metal in accordance with steel structure Painting Council Specification SSPC-SP5-63 using S-170 shot or equivalent.

c. After blasting the pipe surface shall be power wire brushed.

d. The coating shall be applied to the clean preheated (450° to 475°) pipe, using best commercial practice, to a minimum thickness of 7 mils. The thickness shall be determined by using a magnetic thickness gauge. The heat source shall not leave a residue on the pipe surface.

e. The coated pipe shall be maintained at or above 425° for a minimum of 20 seconds for full cure. At the end of this time the pipe shall be water quenched before a supporting roller comes in contact with the coated surface.

f. All epoxy resin coated pipe shall be electrically inspected for holidays using a wet electrode to apply 1000 volts, D. C. across the coating. All imperfections shall be repaired.

g. The epoxy resin coating shall meet the physical requirements as indicated in the table entitled "Physical Requirements of Class A Cured Epoxy Resin Coating."

Physical Requirements of Class A Cured Epoxy Resin Coating

Test Description	Units	Avg. of Specified Determinations	Tolerance of Average
Hardness	Barcol	10	Min.
Mechanical Shock (Gardner Machine)	Inch lbs.	120	Min.
Therman Shock	Cycles	10	Min.
Heat Resistance 100 hour @ 180°C	Percent	4.5	Min.
Adhesion	Lbs/sq. in.	2000	Min.
Salt Water Resistivity	ohm-ft.	1×10^{10}	Min.

Class B Coatings. - When a Class B coating is required, the coating shall meet the requirements of one of the following:

1. Coal-Tar Enamel - The outside of the pipe shall receive a coat of coal-tar primer followed by a hot coat of coal-tar enamel and finished with a Kraft paper or one coat of water-resistant whitewash. All materials and application shall be in accordance with American Water Works Association Specification C 203, except that the asbestos felt wrapper may be omitted.

2. Coal-Tar Enamel with Asbestos Felt Wrap - The outside of the pipe shall receive a coat of coal-tar primer followed by a hot coat of coal-tar enamel into which shall be bonded an asbestos felt wrapper and finished with a Kraft paper or one coat of water-resistant whitewash. All materials and application shall be in accordance with American Water Works Association Specification C 203, except that the minimum thickness of hot coal-tar enamel applied by pouring and spreading may be 1/32 inch.

3. Coal-Tar, Hot Applied Tape and Primer - All materials and workmanship shall be in accordance with Federal Specification HHT-30a, August 2, 1967, Tape, Pipe Coating, Coal Tar, Hot Applied, and Primer.

4. Plastic Tape - Plastic tape coating shall be capable of withstanding the moisture and soil conditions to which it will be subjected. All material shall be in accordance with Interim Federal Specification L-T-001512 for Type I, standard thickness tape, except that the tape coating may be of either rubber material or the specified plastic materials. Application shall be as follows:

   a. The surface of the pipe to be coated shall be cleansed of all foreign material such as oil, grease, dirt, mud, etc. Any knurls, burrs, or other sharp points shall be removed by filing, peening, or wire brushing.

   b. The continuity of the applied plastic coating shall be of such quality that all pipe, joints, and fittings, after assembly shall be capable of passing an inspection test conducted with a spark discharge holiday detector at 1500 volts.

Paint

Paint shall be in accordance with Federal Specifications as specified in "Installation Requirements."

Anodes

Zinc anodes shall be "Special High Grade" zinc which is at least 99.99 percent pure zinc. Magnesium anodes shall have a nominal composition of 6% aluminum, 3% zinc, 0.2% manganese and the remainder magnesium.

Each anode shall have a full length core with a single strand of insulated copper wire solidly attached to it. The wire shall be No. 12 or larger. If a header wire is used, the gauge must be sufficient to carry the design current with no more than a 20 millivolt I-R drop.

All anodes shall be commercially packaged and the packaged backfill mix shall be of the following proportions by weight.

Zinc - 20 to 30% bentonite, 70 to 80% gypsum

Magnesium - 20 to 25% bentonite, 70 to 75% gypsum, 5% sodium sulfate

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION PIPELINE
Reinforced Plastic Mortar

Definition

A pipeline and appurtenances installed in an irrigation system.

Scope

This standard applies to all buried irrigation pipelines constructed of reinforced plastic mortar pipe. It covers the design criteria, minimum installation requirements, and the specifications for the reinforced plastic mortar pipe.

Purpose and Conditions Where Practice Applies

The conservation objectives of this practice are to prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system on a farm or group of farms.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and for the irrigation water application methods to be used.

Design Criteria

Pressure

The pipeline shall be designed to meet all service requirements without an operating or static head at any point greater than the rated operating head of the pipe used at that position in the line.

The minimum acceptable working pressure class shall be pipe having a rated operating head of 50 feet of water.

Depth of Cover

All pipe shall be placed deep enough below the land surface to protect it from the hazards imposed by traffic, farm operations, freezing temperatures or soil cracking. In the trench condition, a minimum cover of two feet shall be provided except in soils subject to

deep cracking or where the pipe is subject to traffic or heavy equipment loads in which cases the minimum cover shall be three feet. Where necessary to place the pipe at lesser depths than indicated above, adequate protection shall be provided by the use of a fence or other surface barrier, or by the use of suitable structural treatment to insure that excessive external loads shall not be transmitted to the pipe.

Where the pipe is installed in the trench condition, the earth cover over the top of the pipe shall not exceed the following heights:

Pipe Diameter (inches)	Maximum Height of Cover for Trench Condition (feet)
8	20
10-12	15
14-18	12
20-48	10

Where the pipe is installed in the embankment condition, the external load shall not exceed a load equivalent to a five-foot earth cover over the top of the pipe.

Capacity

Design capacity shall be based upon whichever of the following is the greater:

1. Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown.

2. Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

Friction Loss

For design purposes, the pipeline friction loss shall be no less than that computed by the Hazen and Williams formula, using a roughness coefficient, c, of 145.

Check Valves, Pressure Relief, Vacuum Release, and Air Release Valves

Where detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure relief valve shall be installed at the pump location when excessive pressure can be developed by operating with all valves closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures could

be developed, a surge chamber or pressure relief valve shall be installed close to the check valve on the side away from the pump.

Pressure relief valves shall be no smaller than 1/4-inch nominal size for each diameter inch of the pipeline, and shall be set at a maximum of 5 p.s.i. above the pressure rating of the pipe.

A pressure relief valve or surge chamber shall be installed at the end of the pipeline when needed to relieve surge.

Air release and/or vacuum release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve when needed to provide a positive means of air entrance or escape.

Air release and vacuum release valve outlets shall be at least 1-inch nominal diameter when specified for lines of 5- to 8-inch diameter, at least 2-inch outlets for lines of 10- to 16-inch diameter, at least 4-inch outlets for lines of 18- to 28-inch diameter, at least 6-inch outlets for lines of 30- to 36-inch diameter, and at least 8-inch outlets for lines of 38- to 48-inch diameter.

For pipelines larger than 16-inch diameter, 2-inch air release valves may be used in place of the sizes indicated above if they are supplemented with vacuum release valves that will provide vacuum release capacity equal to the sizes shown.

<u>Stands and Vents for Low Pressure Lines</u>

Where open stands and/or vents are used in lieu of valves they shall be designed as follows:

<u>Stands</u> - Stands shall be used wherever water enters the pipeline. All stands shall serve as vents in addition to their other functions. All stands will be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. The stand will be designed:

1. To allow a minimum of one foot of freeboard. The stand height maximum above the centerline of the pipeline shall not exceed the working head class of the pipe.

2. With the top at least four feet above the ground surface except for surface gravity inlets which shall be equipped with trash racks and covers.

3. With downward water velocities not in excess of two feet per second. In no case shall the inside diameter of the stand be less than the inside diameter of the pipeline.

The cross sectional area of stands may be reduced above a point one foot above the top of the upper inlet, but in no case shall the reduced cross section be such that it would produce an average velocity of more than 10 feet per second if the entire flow were discharging through it.

When the water velocity of an inlet pipe exceeds three times the velocity of the outlet, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 inches and shall be constructed so that the bottom is at least 24 inches below the invert of the outlet pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 foot per second. Suitable provisions for cleaning sand traps shall be provided.

Gate stands will be of sufficient dimensions to accommodate the gate or gates required and will be large enough to make the gates accessible for repair.

Float valve stands shall be of sufficient size to provide accessibility for maintenance and to dampen surge.

Construction shall be such as to insure that vibrations from the pump discharge pipe is not carried to the pump stand.

Vents - Vents must be designed into the system to provide for the removal of air and for protection from surge. They shall:

1. Have a minimum freeboard of one foot above the hydraulic grade line. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum working head of the pipe.

2. Have a cross sectional area at least one-half the cross sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation, the vent may be reduced to two inches in diameter.

3. Be located as follows:

    a. At the downstream end of each lateral.

    b. At summits in the line.

    c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees.

d. Immediately below the pump stand if the downward velocity in the stand exceeds one foot per second.

Draining and Flushing Requirements

Provisions shall be made for draining the pipeline completely where a hazard is imposed by freezing temperatures or where for any other reason drainage of the line is desirable.

Where provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping.

A suitable valve shall be installed at the distal end of the line when flushing to remove sediment is required.

Outlets

Appurtenances to deliver water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known as outlets. Outlets shall have capacity to deliver the required flow:

1. To a point at least six inches above the field surface.

2. To the hydraulic grade line of a pipe or ditch.

3. To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line, as the case may be.

Thrust Control

Abrupt changes in pipeline grade, horizontal alignment, or reduction in size require an anchor or thrust blocks to absorb any axial thrust of the pipeline.

Thrust blocks and anchors must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure as well as forces due to expansion and contraction.

Materials

All materials shall conform to the minimum requirements of this Standard including Engineering Specifications for Materials.

Installation Requirements

Pipe shall be laid to the lines and grades as shown on the drawings and/or as staked in the field.

Trenches

Pipe trenches shall be straight enough so that the pipeline can be laid without unnecessary deflections at the joints. Where trenches are excavated in soils containing rock or other hard materials, where soils are subject to appreciable swelling and shrinking on wetting and drying, or where the trench bottom is unstable, the trenches shall be over-excavated and backfilled with selected materials as needed to provide a suitable base and uniform support along the full length of the bottom of the pipe. Bell holes shall be excavated as needed to prevent the bells from coming into contact with the subgrade. Any water in the trench shall be drained away or otherwise removed, and pipe laying shall be delayed until a suitable firm base has been obtained.

Placement

The method used to lower the lengths of pipe into the trench and to place them into position shall be such as to prevent damaging the joints or getting dirt inside the pipeline.

Just before each joint is connected, the connecting surfaces of the bell and spigot shall be thoroughly cleaned and dried. The spigot recess, the rubber gasket, and the bell shall be lubricated with an approved gasket lubricant. After lubrication, the gasket shall be thoroughly stretched when it is placed in the spigot groove so that there is a uniform volume of rubber distributed around the circumference of the pipe. The gasket shall not be twisted, rolled, cut, crimped, or otherwise injured or forced out of position during closure of the joint. The position of the rubber gasket shall be checked after joint assembly and if the gasket is not in the proper position, the pipe shall be withdrawn, the gasket checked to see that it is not cut or damaged, the pipe relaid, and the position of the gasket checked again.

When the pipe is laid on tangent, each joint shall be fitted together so that the end of the spigot of one pipe is as close to being in contact with the shoulder of the bell of the adjacent pipe as practicable. On curves, the maximum deflection at any one joint shall not exceed three degrees for pipe sizes up to 30 inches in diameter and 1-1/2 degrees for larger sizes.

Testing

The pipeline shall be thoroughly and completely tested for pressure strength and leakage before backfill operations are undertaken. The line shall be filled with water, taking care to bleed all entrapped air in the process. The pressure shall be slowly built up to a maximum design working pressure. The line shall be inspected in its entirety while the maximum working pressure is maintained. Where leaks are discovered, they shall be promptly repaired and the line shall be retested. In cases where it is necessary to partially backfill the line before testing in order to hold the line in place, the backfill shall cover only the body of the pipe sections, leaving all joints and connections uncovered for inspection purposes. Any backfill so placed shall be placed in accordance with the provisions specified under backfilling.

It shall be demonstrated by testing that the pipeline and all valves, vents, surge chambers, and other appurtenances function properly when the pipeline is operated at design capacity. Objectionable surge, water hammer, unsteady delivery of water, damage to the pipeline, and detrimental discharge from control valves are evidence of malfunction.

Backfilling

Trench backfill shall be so placed that the pipe will not be displaced, excessively deformed, or damaged. The initial backfill shall be of selected mineral soils, sands, or gravels free from rocks or stones larger than one inch in diameter and earth clods greater than approximately two inches in diameter. At the time of placement, the moisture content of the backfill material shall be such that the required degree of compaction can be obtained with the equipment to be used. The materials shall be brought up at approximately the same rate on both sides of the pipe and shall be compacted firmly around the pipe to achieve a density equal to or exceeding the natural density of the undisturbed side walls of the trench. This initial compacted backfill shall extend at least to a height of 0.7 of the vertical outside diameter of the pipe.

When water packing is used, the pipeline shall be filled with water. The initial backfill, before wetting, shall be of sufficient depth to insure complete coverage of the pipe after consolidation has taken place. Sufficient water to completely saturate the backfill material shall then be flushed into diked reaches of the trench. The amount of water shall be controlled to insure that pooling of excess water does not occur. The wetted fill must be allowed to dry until firm before final backfill is begun.

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Final backfill material shall be free of large rocks or boulders, and shall be added to the trench in a manner that will not cause damage to the pipe. This material need not be compacted, but shall be mounded over the top of the trench in a manner that will leave the fill at ground level after settlement.

Repairs

Individual pipe units may be repaired when the defects are the result of occasional imperfections in pipe manufacture or accidental damage during handling. All repairs must be made by methods approved by the Soil Conservation Service. Such repairs must be sound, properly finished and cured, and the repaired pipe must conform to the requirements of these specifications as to dimensions and tolerances. Hydrostatic tests may be required on any repaired pipe if deemed necessary by the purchaser.

Plans and Specifications

Plans and specifications for Reinforced Plastic Mortar Irrigation Pipeline shall be in keeping with this Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Pipe Classes

Reinforced plastic mortar pipe shall be classified in accordance with its rated operating head in feet of water. The classes are designated RPM 50, RPM 100, RPM 200, RPM 250, and RPM 300.

Definition

A lot as used herein means one hundred (100) lengths of pipe or fraction thereof of identical class and size manufactured in a single production run. A unit means a length of pipe or a portion of a length of pipe.

Pipe Material

Reinforced plastic mortar pipe shall be composed of an aggregate filler, a glass fiber reinforcement, and a resin binder.

Filler - The aggregate filler shall be a siliceous natural sand conforming to the requirements for concrete aggregate (ASTM Designation C-33) except that the requirements for gradation shall not apply.

Reinforcement - The reinforcement shall be manufactured from continuous rovings of borosilicate type glass fibers with a polyester compatible finish.

Binder - The binder shall be a catalyzed isophthalic polyester resin with or without inorganic fillers.

Physical Requirements

All pipe furnished under these specifications shall meet the following test requirements for soundness, hoop tensile strength, and stiffness factor. The tests shall be performed by the manufacturer at his expense. Certified copies of the results of the tests shall be furnished the Soil Conservation Service upon request.

Soundness - Each pipe unit shall be tested to withstand without leakage a hydrostatic proof test for soundness of not less than the head designated in Table 1. The hydrostatic proof test shall be conducted by placing the pipe in a hydrostatic pressure testing device which seals the ends and exerts no end loads. The pipe shall be filled with water, expelling all air, and the internal water pressure shall be increased at a uniform rate not to exceed 230 feet of water per second until the specified proof pressure is reached. The pipe shall be maintained at the hydrostatic proof test pressure for a sufficient time to determine that the soundness requirements are met, but for a minimum of five seconds.

Table 1

Minimum Required Hydrostatic Proof Test Pressures

Pipe Class	Hydrostatic Proof Pressure Head (Feet of Water)
RPM 50	100
RPM 100	200
RPM 150	300
RPM 200	400
RPM 250	500
RPM 300	600

Ultimate Hoop Tensile Strength - At least one pipe length of each size and class of pipe manufactured in each separate production run shall be tested for hoop tensile strength. Additional tests, up to one pipe length out of each lot, may be required. From each pipe length chosen for testing, one section two feet long shall be selected for hoop tensile strength tests.

Hoop tensile strength shall be determined by the Split-Disk Method, ASTM Designation D 2290, except that Sections 4 and 5 may be modified to suit the size of specimens to be tested and Sections 6, 8(d), 8(f), 9 and 10 shall not apply. Three ring specimens shall be cut from the two-foot long sample. The load to fail each specimen shall be recorded and the specimen width shall be determined as close to the break as possible. The averages of the three loads and the three widths shall be used to calculate the load in pounds per inch of width, and this load must meet the requirements shown in Table 2.

If the average of the three specimens fails to meet the requirements in Table 2, two more two-foot long sections shall be taken from two additional pipe lengths in the production run and the hoop tensile strength tests shall be repeated on specimens cut from each. Failure of either group of retest specimens to meet the requirements of Table 2 shall cause the entire production run to be rejected.

Table 2

Ultimate Hoop Tensile Strength
(Pounds/Inch of Width for Split Disk Failure)

Pipe Size (Inches)	Pipe Class RPM 50	RPM 100	RPM 150	RPM 200	RPM 250	RPM 300
8	390	780	1170	1560	1950	2340
10	488	975	1465	1950	2440	2925
12	585	1170	1755	2340	2925	3510
14	683	1365	2045	2730	3415	4100
15	731	1462	2195	2924	3655	4390
16	780	1560	2340	3120	3900	4680
18	878	1755	2630	3510	4390	5270
20	975	1950	2925	3900	4875	5850
21	1023	2045	3069	4090	5115	6130
24	1170	2340	3510	4680	5850	7020
27	1318	2635	3950	5270	6590	7900
30	1465	2930	4390	5860	7325	8790
33	1610	3220	4830	6440	8050	9660
36	1755	3510	5270	7020	8775	10530
39	1900	3800	5700	7600	9500	11400
42	2048	4090	6135	8180	10240	12300
45	2195	4390	6590	8780	10975	13170
48	2340	4680	7020	9360	11700	14040

Stiffness Factor - From the pipe lengths selected as described above for the hoop tensile strength test, one section one-foot long shall be selected for stiffness factor tests.

The stiffness factor (SF) at five percent deflection shall be determined for the sample using the apparatus and procedure of the Method of Test for External Loading Properties of Plastic Pipe by Parallel Plate Loading, ASTM Designation D 2412, with the following exceptions:

A. Section 5.1 - The test specimen shall be 12± 1/8 inches in length.

B. Section 5.2 - Only one specimen shall be required.

C. Section 6.1 - The specimen shall be conditioned and tested at ambient temperature and relative humidity.

D. Section 7.1 - The wall thickness shall be measured to the nearest 0.01 inch.

E. Section 7.6 - The specimen shall be tested to five percent deflection and the stiffness factor determined. Crazing or checking of pipe surfaces shall not be allowed at a deflection of five percent. The specimen shall then be loaded to a deflection of 15 percent without evidence of structural damage.

Structural damage is defined as any visible distress of the structural wall evidenced by interlaminar separations, tensile failure of the glass fiber reinforcement and/or buckling.

The stiffness factor of the test specimen shall meet the requirements of Table 3.

If the pipe section selected for stiffness factor testing fails to meet the requirements of Table 3, two more one-foot long sections shall be taken from two additional pipe lengths in the production run and subjected to stiffness factor testing. Failure of either retest specimen shall cause the entire production run to be rejected.

Table 3

Minimum Stiffness Factor (SF) for RPM Pipe at Five Percent Deflection

Nominal Size (Inches)	SF Minimum (in^2 - lb/in)
8	1000
10	1000
12	1200
14	1400
15	1400
16	1670
18	1950
20	1950
21	2100
24	3000
27	4000
30	5500
33	7400
36	9200
39	11500
42	13500
45	16000
48	18000

Gaskets

The term "rubber gaskets" as used in these specifications shall be construed to include natural rubber, synthetic rubber, or a blend of both. Rubber gaskets shall be extruded or molded and cured in such a manner that any cross section will be dense, homogeneous, and free from porosity, blisters, pitting, and other imperfections. They shall conform to the requirements of ASTM Specification C 361, Section 4.10.

Joints

Pipe shall be furnished with bell and spigot ends for joining, with a solid, uniform cross section rubber gasket being used as the sealing element. The gasket shall be contained in a groove and shall not support the weight of the pipe when two sections are joined. The joint assemblies shall be so formed that when pipe sections are drawn together, the pipe shall form a continuous watertight conduit, and shall provide for slight movements of any pipe in the pipeline due to expansion, contraction, settlement, or lateral displacement. The rubber gasket shall be the sole element of the joint depended upon to provide a watertight seal.

The volume of the gasket shall be less than 85 percent of the volume of the annular space in which the gasket is to be contained with the engaged joint in concentric position. The gasket shall not be stretched more than 20 percent of its original length when fully seated in the groove. The gasket shall be of such diameter that when the outer surface of the spigot and the inner surface of the bell come into contact at some point in their periphery, the deformation in the gasket shall not exceed 40 percent at the point of contact nor be less than 15 percent at any point. Stretched gasket diameters shall be calculated as being the original diameter divided by the square root of (1 + X), where "X" is the percent of gasket stretch divided by 100. Determination of gasket deformation in an off-center joint shall be based on the most unfavorable limits of the pipe manufacturer's tolerances.

Fittings

Fittings, such as tees, elbows, wyes, reducers, and adaptors may be (1) reinforced plastic mortar fittings fabricated by the pipe manufacturer from pipe meeting the requirements for soundness as specified under "Physical Requirements," (2) cast iron fittings, or (3) fabricated steel fittings. All connections between steel, cast iron, or RPM fittings and RPM pipe shall be made with rubber gasket joints.

All steel fittings shall be protected from corrosion by an epoxy resin coating as described under Class A coatings in the Soil Conservation Service Standard and Specifications Guide for Irrigation Pipeline (Steel), Code 432-F.

Dimensions

Length - The nominal laying length of RPM pipe units shall not exceed 20 feet, with a plus or minus tolerance of one inch.

Inside Diameter - The average inside diameter, measured about six inches from the end of the pipe, shall not vary from the nominal diameter by more than 1/4 inch or 1.0 percent of the nominal diameter, whichever is greater. The average internal diameter shall be determined from four equally spaced diametric measurements.

Workmanship

The inside surface of the pipe shall be free of bulges, dents, ridges, grooves, or other irregularities that have a depth or a height of more than 1/16 inch as measured from the normal level of the surrounding surface.

Joint sealing surfaces shall be free of dents and gouges that will affect the integrity of the joints.

No glass fiber reinforcement shall be exposed on either the interior or the exterior surface of the pipe.

Marking

Each length of pipe and each reinforced plastic mortar fitting shall be marked with the size and class of pipe, date of manufacture, and the name or trade mark of the manufacturer.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

Irrigation Pit or Regulating Reservoir
IRRIGATION PIT

Definition

A small storage reservoir constructed to regulate or store the supply of water available to the irrigator.

Scope

This standard includes open pits excavated below the ground surface to intercept and store either surface water or unconfined groundwater for irrigation. It includes pits where a portion of the water is impounded above natural ground, provided that the depth of water above the ground surface, as measured at the spillway crest elevation, does not exceed 3 feet. It does not apply to excavated pits designed primarily for the control or regulation of flow where storage is not a major feature.

The standard establishes the minimum acceptable quality level for the planning and functional design of irrigation pits. It does not include detailed design criteria or construction specifications for individual pits or components of the storage facility.

Purpose

Irrigation pits are constructed to collect and store water until it can be used beneficially to satisfy crop irrigation requirements.

Conditions Where Practice Applies

This practice applies only to sites meeting all of the following criteria and conditions:

1. The existing water supply available to the irrigated area is insufficient to meet conservation irrigation requirements during part or all of the irrigation season.

2. The construction of an irrigation pit is the most practical means of developing the needed additional supply of water.

3. An adequate supply of good quality water is available for storage from surface runoff, streamflow, or from a subsurface source.

4. Topographic, geologic, water table, and soils conditions at the site are satisfactory for the feasible development of the irrigation pit.

5. Where surface runoff enters the pit, the contributing drainage area is or can be protected against erosion to the extent that normal sedimentation will not materially shorten the planned life of the pit.

6. The contemplated excavation of the pit and storage of water are permitted by applicable State statutes and regulations.

Design Criteria

Capacity Requirements

Irrigation pits shall be designed to have a usable capacity sufficient to satisfy irrigation requirements in the design area throughout the growing season of the crop or crops being irrigated. In computing capacity requirements, due consideration shall be given where applicable to groundwater inflow, surface runoff, precipitation, evaporation and seepage. Additional capacity shall be provided as necessary for sediment storage. The usable capacity of a pit that depends wholly on groundwater as a source of supply shall be that portion of the pit that is below the static water level.

Side Slopes

Side slopes of irrigation pits shall be no steeper than those required to maintain slope stability in the type of material encountered.

Inlet Protection

Where surface runoff enters the pit through a natural or excavated channel, the side slope of the pit shall be protected against erosion by the use of a suitable structure.

Embankment and Spillway Requirements

Where irrigation pits supplied by surface runoff are located on sloping terrain, and a portion of their capacity is impounded against an embankment, the embankment shall be designed to comply with the Soil Conservation Service Engineering Standard for Farm Pond and a suitable spillway shall be provided to pass excess storm runoff either around, through, or under the embankment. The capacity of the spillway shall be no less than that required to accommodate the peak rate of runoff that can be expected to be equalled or exceeded once in 10 years.

Placement of Waste Material

Waste material excavated from the pit shall be placed or disposed of in such a manner that its weight will not endanger the stability of the pit side slopes and where it will not be washed back into the pit as a result of rainfall. To accomplish these objectives, the

waste material may be placed in one of the following ways:

1. Uniformly spread to a height not exceeding 3 feet with the top surface graded to a continuous slope away from the pit. In such cases no berm is required.

2. Uniformly stacked with side slopes assuming the natural angle of repose for the excavated material behind a berm equal in width to the maximum depth of the pit but not less than 12 feet. The maximum height of the waste bank shall not exceed 12 feet.

3. Removed from the site and utilized elsewhere.

Outlet Works

Suitable outlet works shall be provided for the controlled release of irrigation water. The capacity of the outlet works shall be no less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

Plans and Specifications

Plans and specifications for Irrigation Pits shall be in keeping with the preceding standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

Irrigation Pit or Regulating Reservoir
REGULATING RESERVOIR

Definition

Small storage reservoir constructed to regulate or store the supply of water available to the irrigator. Sometimes referred to as overnight storage reservoir.

Scope

This standard includes reservoirs created by impounding structures and pits excavated below ground surface for the short-period storage of either diverted surface waters or waters from pumped or flowing wells.

The depth of water in regulating reservoirs created by impounding structures shall not exceed 20 feet, measured as the vertical distance between the lowest point along the centerline of the embankment and the crest elevation of the emergency spillway.

This standard establishes the minimum acceptable quality level for the planning and functional design of irrigation regulating reservoirs. It does not include detailed design criteria or construction specifications for individual reservoirs or components of the regulating facility.

Purpose

Regulating reservoirs are constructed to store water for relatively short periods of time for such purposes as:

1. To provide for the regulation of fluctuating flows in streams or canals.

2. To provide suitable (usually larger) irrigation streams.

3. To provide for improved management of irrigation water.

4. To permit more efficient use of available labor.

5. To avoid nighttime operation.

Conditions Where Practice Applies

This practice applies only to sites meeting all of the following criteria and conditions:

1. The existing available irrigation stream is of such size that regulation is necessary to accomplish the intended purposes.

2. An adequate and dependable volume of good quality water is or can be made available.

3. Topographic, geologic, and soils conditions are suitable for the practical construction of a regulating reservoir with an adequate storage capacity. Pervious soils encountered in the reservoir area can be sealed to such degree that seepage losses will not be excessive.

4. Where surface runoff enters the reservoir, the contributing drainage area is or can be protected against erosion to the extent that normal sedimentation will not materially shorten the planned life of the reservoir.

5. The owner will have, or be able to obtain, a valid right to use the water.

Design Criteria

Compliance with State Laws

The design, construction, and registration of all regulating reservoirs shall be in strict compliance with all State water laws and regulations pertaining thereto.

Capacity Requirements

Irrigation regulating reservoirs shall have a usable capacity sufficient to permit the existing irrigation stream to be so regulated that irrigation water may be applied with a reasonably high efficiency. In computing capacity requirements, due consideration shall be given where applicable to diverted inflow, surface runoff, precipitation, evaporation, and seepage. Excessive seepage losses shall be prevented by the use of an adapted method of sealing or lining. Additional capacity shall be provided as necessary for sediment storage.

Foundation and Embankment Design

For impounding structures, the foundation, the embankment, and all needed related appurtenances shall be designed to comply with the Soil Conservation Service Engineering Standard for Farm Pond (Code 378) and with other SCS standards applicable to the type and class of structure involved.

Overflow Protection

A trickle tube, pipe drop inlet, or other suitable device shall be provided for protection against overflow resulting from flows of long duration. The capacity of the overflow structure shall be at least equal to the normal inflow stream. Overflow protection structures may be designed and installed in combination with the outlet works.

Outlet Works
Outlet works shall be provided for the controlled release of irrigation water. The outlet works may consist of a gated conduit through or over the embankment for gravity flow to the irrigated area or to a pumping plant, or they may consist of a pumping plant designed to lift water directly from the reservoir basin. The capacity of the outlet works shall be no less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

Inlet Protection
Where the inflow enters the reservoir, the side slope of the reservoir shall be protected against erosion by the use of a pipe inlet or some other suitable structure. The capacity of the inlet structure shall be no less than that required to accommodate the maximum anticipated rate of inflow.

Side Slopes
Side slopes of excavated regulating reservoirs shall be no steeper than those required to maintain slope stability in the type of material encountered, and in no case shall they be steeper than 1 horizontal to 1 vertical.

Placement of Waste Material
In the case of excavated regulating reservoirs, the waste material shall be placed or disposed of in such a manner that its weight will not endanger the stability of the side slopes and where it will not be washed back into the reservoir as a result of rainfall. To accomplish these objectives, the waste material may be placed in one of the following ways:

1. Uniformly spread to a height not exceeding 3 feet with the top surface graded to a continuous slope away from the reservoir. In such cases, no berm is required.

2. Uniformly stacked with side slopes assuming the natural angle of repose for the excavated material behind a berm equal in width to the maximum depth of the reservoir but not less than 12 feet. The maximum height of the waste bank shall not exceed 12 feet.

3. Removed from the site and utilized elsewhere.

Plans and Specifications

Plans and specifications for Irrigation Regulating Reservoirs shall be in keeping with the preceding standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION STORAGE RESERVOIR

Definition

An irrigation storage reservoir made by constructing a dam.

Scope

This standard applies to irrigation water storage structures designed to be filled during the season of low irrigation demand in order to provide water needed for irrigation during some other portion of the year, or in some future year. It does not apply to structures designed primarily for flow control or those designed to store water for only a few hours or a few days.

This standard covers the planning and functional design of irrigation storage reservoirs. It does not include detailed design criteria or construction specifications for individual structures or components of the storage facility.

Purpose

Irrigation storage reservoirs are constructed to conserve water by holding it in storage until it can be beneficially used to meet crop irrigation requirements.

Conditions Where Practice Applies

This practice applies only to sites meeting all of the following criteria:

1. The water supply available to the irrigated area is insufficient to meet conservation irrigation requirements during part or all of the conservation season.

2. Water is available for storage from surface runoff, streamflow, or from a subsurface source during periods of low or non-irrigation use.

3. Topographic, geologic, and soils conditions are satisfactory at some suitable site for the development of an economically feasible storage reservoir.

4. The construction of a dam and the storage of water are permitted by applicable state statutes and regulations.

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Design Criteria

Irrigation Requirements

The amount of water required to properly irrigate the crops in the area to be irrigated and the variations in water demand within the growing season must be known in order to adequately evaluate storage requirements. All demand hydrographs shall be computed from the consumptive use-time relationship, increased to reflect the anticipated level of farm irrigation efficiency plus any losses to be expected in conveying the water from the point of diversion to the farm and field. When water is required for such purposes as leaching or frost control, the amount so needed shall be included in the demand hydrograph.

Storage Requirements

Irrigation storage reservoirs shall be designed to have a usable capacity sufficient to satisfy irrigation requirements in the design area unless limited by characteristics of the reservoir site or by the available watershed yield (including limitations imposed by water rights). Additional capacity shall be provided as needed for sediment storage.

The stored water releases required to meet irrigation demands will be those increments of the water demand hydrograph that exceed the available direct flows from other sources.

Capacity to Meet Irrigation Demand

In computing the reservoir capacity required to satisfy irrigation demands, due consideration shall be given to the length of the storage period, the anticipated inflow during this period, and the seepage and evaporation losses to be expected under the proposed plan of operation.

Capacity Limited by Site Characteristics or Watershed Yield

If the storage capacity is limited by the characteristics of the site to less than that required to meet the irrigation demands of the proposed area or if the water supply available for storage is insufficient to meet these demands, the quantity of water that can be made available at the reservoir outlet and the acreage that can adequately be irrigated shall be computed as a means of evaluating the benefits of the proposed installation. In some cases, the benefits may be evaluated on the basis of the more frequent availability of water to satisfy irrigation demands for the full design area.

Type of Structures

The type of dam and appurtenant structures to be used shall be individually selected for each site on the basis of hydrologic studies and engineering and geologic investigations of the site conditions and the materials available for construction.

Dam Design
All dams and related appurtenant structures shall be designed to meet applicable Soil Conservation Service standards for the type and class of structure involved.

Outlet Works
Outlet works shall be provided for the controlled release of irrigation water. The outlet works may consist of a gated conduit through or over the dam for gravitational flow to the irrigated area or to a pumping plant, or they may consist of a pumping plant designed to lift water directly from the reservoir basin.

The capacity of the outlet works shall be not less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

Plans and Specifications

Plans and Specifications for construction of Irrigation Storage Reservoirs shall be in keeping with this Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION SYSTEM, SPRINKLER

Definition

A planned irrigation system where all necessary facilities have been installed for the efficient application of water for irrigation by means of perforated pipes or nozzles operated under pressure.

Purpose

Sprinkler irrigation systems are installed to apply irrigation water efficiently and uniformly in order to maintain soil moisture within the range for optimum plant growth, without excessive water loss, erosion or reduction in water quality.

Conditions Where Practice Applies

Sprinkler irrigation plans shall be based on an evaluation of the site and the expected operating conditions. The soils and topography shall be suitable for irrigation for the proposed crops.

Enough good-quality water shall be available for the practical irrigation of the crops to be grown.

The sprinkler method of water application is adaptable to most crops except rice, to most irrigable lands, and to most climatic conditions where irrigated agriculture is feasible.

Design Criteria

Depth of Application

The net depth of application shall be based on the available moisture-holding capacity of the soil within the root-zone depth of the crop irrigated. The gross depth shall be determined by using field application efficiencies consistent with the conservation use of water resources.

Capacity Requirements

In regularly irrigated areas, sprinkler irrigation systems shall have a design peak capacity adequate to meet the moisture demands of each and all crops to be irrigated within the design area. In computing capacity requirements, allowance must be made for reasonable water losses during application periods.

Systems for special-purpose irrigation shall have the capacity to apply a stated amount of water to the design area in a specified net operating period.

Design Application Rate

The design rate of application shall be within a range established by the minimum practical application rate under local climatic conditions, and the maximum rate consistent with the intake rate of the soil. Where two or more sets of conditions are found in the design area, the lowest maximum application rate for areas of significant size will apply.

Distribution Patterns and Spacing Requirements

A combination of sprinkler spacing, nozzle sizes, and operating pressure shall be selected that will most nearly provide the design application rate and distribution. Prevailing wind velocities and other unfavorable operating conditions also must be considered.

Where available from the manufacturers, uniformity coefficient data shall be used to select sprinkler spacing, nozzle sizes, and operating pressure. In such cases, the uniformity coefficient shall be not less than 85 percent.

In the absence of such data, sprinkler performance tables provided by the manufacturers shall be used to select the nozzle sizes, operating pressure, and wetted diameter for the required sprinkler discharge. The maximum spacing shall comply with the following criteria:

1. For low, intermediate, and moderate-pressure sprinklers, the spacing along lateral lines (S_1) shall not exceed 50 percent of the wetted diameter as given in the manufacturer's performance tables when the sprinkler is operating under optimum pressure. The spacing of laterals along the main line (S_m) shall not exceed 65 percent of this wetted diameter. Where wind can be expected, spacing (S_m) shall be reduced to 60 percent for average velocities of 5 miles per hour, to 50 percent for average velocities of 10 miles per hour, and to 30 percent for average velocities greater than 10 miles per hour.

2. For high-pressure sprinklers and for the giant hydraulic type, the maximum (diagonal) distance between two sprinklers on adjacent lateral lines shall not exceed two-thirds of the wetted diameter under favorable operating conditions. Where wind can be expected, the diagonal spacing shall be reduced to 50 percent of the wetted diameter for average velocities of 5 miles per hour and to 30 percent for average velocities greater than 10 miles per hour.

For perforated pipe lines, the spacing recommendations of the manufacturer for the design application rate, number and size of perforations and operating pressure shall be followed.

Lateral Lines

Lateral lines shall be so designed that the total pressure variation at the sprinkler heads, due both to friction head and static head, will not exceed 20 percent of the design operating pressure of the sprinklers.

Except for under-tree operation, riser pipes used in lateral lines shall be long enough to prevent interference with the distribution pattern when the tallest crop is being irrigated. In no event shall riser lengths be less than shown in the following table:

Sprinkler Discharge	Riser Length
g.p.m.	inches
Under 10	6
10 to 25	9
25 to 50	12
50 to 120	18
Over 120	36

Main Lines

Main lines, sub-mains and supply lines shall be designed so as to convey the quantities of water required to all lateral lines at the maximum required pressure.

Where the pressure required for sprinkler system operation is provided by pumping, main line pipe sizes shall be so selected that an economical balance between the capitalized cost of the pipe and annual pumping costs will result.

Pump and Power Unit

The pump capacity and the power unit shall be adequate to operate the sprinkler system efficiently when maximum capacity is being pumped against maximum total dynamic head.

Plans and Specifications

Plans and specifications for construction of Irrigation Sprinkler Systems shall be in keeping with the preceding standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION SYSTEM, SURFACE AND SUBSURFACE

Definition

A planned irrigation system where all necessary water control structures have been installed for the efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.

Scope

This standard covers the planning and design of the overall irrigation water distribution and waste water disposal system for a farm or farming unit. It does not include detailed design criteria and construction specifications for individual structures or components of the system, or for the methods of irrigation water application to be used.

Purpose

Surface and subsurface irrigation systems are installed to efficiently convey and distribute irrigation water to the point of application without excessive erosion, water losses, or reduction in water quality.

Conditions Where Practice Applies

Irrigation systems shall be planned and installed to serve only lands that are suitable for use as irrigated land with the quality of water available. Water supplies must be sufficient in quantity and quality to make irrigation practical for the crops to be grown and also must be adequate for the water application methods to be used.

Each irrigation system shall be designed as an integral part of an overall plan of conservation land use and treatment for the farm that is based on the capabilities of the land and the needs of the farm enterprise.

Design Criteria

Land Treatment Units

Lands differ in their irrigation requirements. Coarse textured soils must be irrigated differently than fine textured soils. Shallow soils have different requirements than deep soils. Steep slopes have more stringent irrigation limitations than gentle

slopes. Irrigation Guides show the irrigation requirements for each significantly different combination of soil and slope condition (land treatment unit). All conservation farm irrigation systems shall be designed to meet the particular needs of the various land treatment units to be served.

Conservation Irrigation Methods
All farm irrigation system designs shall be based on the use of conservation water application methods that are adapted for the site conditions (combination of soil and slope) and the crops to be grown. Adapted methods are those methods that will provide for efficient use of water without destructive soil erosion.

Capacity of System
The capacity of the system and its component parts shall be adequate to meet the peak use requirements of the crops to be grown and the required rate of water delivery for the irrigation methods to be used.

Where various irrigation methods will be used on the same field, the system capacity must be adequate for the method requiring the highest rate of water delivery. Likewise, where crops with different peak use requirements are to be grown, the system capacity must be based on the crop having the highest use rate.

All ditches and other structures shall be constructed of sufficient size to permit the delivery of required quantities of water without overtopping. All structures shall be designed for the maximum flow conditions to be expected, and shall provide for a freeboard consistent with their size and construction and in accordance with appropriate Service standards.

Water Surface Elevations
All systems for irrigation by surface methods shall be designed so the water surface elevation at field takeout points is sufficient to provide the required flow onto the field surface. A head of at least 4 inches shall be provided.

Subsurface irrigation systems shall be designed to hold the water table at or between pre-determined elevations below the ground surface at all points in the design area.

Location of Head Ditches or Pipelines
Head ditches, or pipelines used for surface irrigation shall be located so that irrigation water can be applied uniformly over the entire field without erosion. Ditch or pipeline spacing shall be such that irrigation runs will not be longer than the maximums specified in the local Irrigation Guide or that determined by adequate field evaluations. Where more than one kind of crop is to be grown or more than one method of irrigation is to be used, the ditch or pipeline spacing shall not exceed the allowable length of run as determined for the limiting crop or method.

Feeder ditches or conduits for subsurface irrigation shall be spaced so that the variation in depth from the land surface to the water table will not be greater than is permissible for adequate irrigation of the limiting crop to be grown.

Erosion Control

The design of farm irrigation systems must provide for the conveyance and distribution of irrigation water without damaging soil erosion. All unlined ditches shall be located on non-erosive gradients. Where water must be conveyed down slopes that are steep enough to cause excessive flow velocities, the irrigation system design shall provide for the installation of erosion control structures such as drops, chutes, buried pipe lines, or erosion resistant ditch linings.

Water Control

Farm irrigation systems shall include such structures as measuring devices, division boxes, checks, turnouts, pipelines, lined ditches, valves, and gates as needed to control and regulate the water for efficient application.

Seepage Control

Seepage from irrigation system ditches can damage land and waste water resources. Therefore, except where seepage is specifically desired for subsurface irrigation, designs shall provide for minimizing these losses.

For surface irrigation systems, ditches preferably should be located so they do not cross areas of highly permeable soils. Where site conditions require the conveyance of water across gravelly, sandy, or other excessively permeable areas, the irrigation system design shall provide for the use of pipe lines, flumes, or lined ditches as needed to prevent excessive losses of water by seepage into the soil.

Waste Water Disposal

Irrigation system designs shall include facilities of adequate capacity for the safe removal of excess irrigation and storm water from the field surface. Pickup or waste water ditches constructed for this purpose must be on non-erosive gradients, or must be stabilized by lining or structural measures where erosion hazards exist. Where field elevations do not permit the disposal of waste water by gravity flow, the design shall provide for the installation of pumping units and other needed appurtenant structures.

Waste water ditches must be protected against bank erosion by the use of structures for the entry of waste water, or by the establishment of a vegetative cover on gently-sloping banks.

Where excess water will be re-used as irrigation water, the irrigation system design shall provide for pickup ditches so that water does not flow directly from furrows or borders into irrigation head ditches.

Plans and Specifications

Plans and specifications for Surface and Subsurface Irrigation Systems shall be in keeping with the preceding standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION SYSTEM, TAILWATER RECOVERY

Definition

A facility to collect, store, and transport irrigation tailwater for re-use in the farm irrigation distribution system.

Scope

This standard covers the planning and functional design of irrigation tailwater recovery systems including pickup ditches, sumps, pits, and pipelines. It does not include detailed design criteria or construction specifications for individual structures or components of the recovery system.

Purpose

Tailwater recovery systems are installed to conserve farm irrigation water supplies and water quality by collecting the water that runs off the field surface and making this water available for re-use on the farm.

Conditions Where Practice Applies

Tailwater recovery systems are adapted for use on sloping lands that are served by a surface irrigation system properly designed and installed to facilitate the conservation use of soil and water resources, and where recoverable irrigation runoff occurs or can be anticipated under the management practices used or expected to be used.

Design Criteria

Collection Facilities

Facilities for the collection of irrigation tailwater are an integral part of a surface irrigation system designed and constructed as described in the Soil Conservation Service National Engineering Standard and Specifications Guide for Irrigation Systems, Surface and Subsurface.

Sump or Pit

A sump or pit is needed to store the collected tailwater until such time as it is redistributed in the farm irrigation system. The desired control of water at the point where the tailwater is returned to the irrigation system shall be considered in determining the size of the sump.

Small sumps with frequently cycling pumping plants may be used where the tailwater discharges into an irrigation regulation reservoir or into a pipeline with the flow controlled by a float valve. However, where the irrigation distribution system does not include facilities for regulating fluctuating flows, tailwater sumps shall be made large enough to provide the regulation needed to permit efficient use of the water.

Sumps shall be equipped with inlets designed to protect the side slopes and the collection facilities from erosion. A dike or ditch shall be provided where necessary to limit the entrance of surface water to the designed inlet. Sediment traps shall be installed where needed.

Sumps or pits shall be designed and constructed in accordance with applicable Soil Conservation Service Standards and Specifications.

Return Facilities
All tailwater recovery systems require facilities of some kind to convey the tailwater from the storage sump to the point of re-entry into the farm irrigation system. These facilities may consist of a pump and pipeline to return the water to the upper end of the field, or they may consist of a gravity outlet with a ditch or pipeline to convey the water to a lower section of the farm irrigation system.

The capacity of return facilities shall be determined by an analysis of expected runoff rates, the proposed sump storage capacity, and the anticipated use to be made of the tailwater.

Where the return flow is used as an independent irrigation stream rather than as a supplement to the primary irrigation water supply the rate of flow must be adequate for the methods of water application employed.

Pipelines, lined or unlined ditches, and pumping plants used in return facilities shall be designed and constructed in accordance with applicable SCS Engineering Standards and Specifications.

Plans and Specifications

Plans and specifications for Irrigation Tailwater Recovery Systems shall be in keeping with the preceding standard and shall describe the essential requirements for proper installation of the practice to achieve its intended purpose.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

IRRIGATION WATER MANAGEMENT

Definition

Irrigation water management is the use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture-holding capacity of the soil and the need of the crop, where the water is applied at a rate and in such a manner that the crops can use it efficiently, and where significant erosion and loss of water quality does not occur. It includes the timing of irrigations to meet crop needs, the control and adjustment of stream sizes to prevent erosion, and the control of lengths of "set" to reduce water losses.

Purpose

The purpose of water management is to accomplish efficient, beneficial use of irrigation water according to the moisture needs of the crop and to minimize losses of soil, plant nutrients, and water quality.

Conditions Where Practice Applies

This practice is adapted to all lands that are suitable for irrigation and that have a water supply of suitable quality and quantity.

An adapted conservation irrigation system must be available, either as a portable system or a system that has been established on the land to be irrigated.

Means must be available for determining application rates, irrigation stream sizes, elevation of controlled water tables, and rates of flow of surface runoff where these measurements are applicable to the irrigation method being used.

The irrigator shall have the knowledge and capability to manage and apply irrigation water in such a manner that the objectives mentioned above under "Purpose" can be reasonably attained. The knowledge should include such things as:

1. The consumptive use rates for the crops grown.

2. How to measure or estimate the amount of water required for each irrigation.

3. How to determine when irrigation water needs to be applied.

4. How to recognize erosion caused by irrigation.

5. How to compute the amount of water delivered to an area.

6. How to estimate the amount of irrigation runoff from an area.

7. How to evaluate the uniformity of water application.

8. The normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rate.

9. How to adjust stream size and irrigation time if necessary to compensate for changes in such factors as intake rate or amount of water to be applied.

See page S-449-1 for items to be considered in the application of this practice to achieve the intended purposes.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

LAND CLEARING

Definition

Removing trees, stumps, and other vegetation from wooded areas.

Purpose

To achieve needed land use adjustments and improvements in the interest of soil and water conservation and in keeping with the capabilities of the land.

Conditions Where Practice Applies

This practice applies to wooded areas where the removal of trees, stumps, brush and other vegetation is needed in carrying out a soil and water conservation plan, and the land to be cleared will be used in accordance with its capabilities.

Planning Criteria

The plan shall specify the kinds of timber to be salvaged, lengths of logs and place of stacking. Method of disposal shall be specified for all material not to be salvaged. Clearing and disposal methods shall be in accordance with applicable State laws and with due regard to the safety of persons and property.

The cleared area shall be left in a neat and sightly condition that will facilitate the planned use and treatment of the land.

The plan shall provide for the measures necessary to protect the cleared area from erosion.

Special attention will be given to maintaining or improving habitat for fish and wildlife where applicable. Consideration of such things as strip clearing, windrowing debris, and maintaining of den and food trees should be explored.

Plans and Specifications

Plans and specifications for installation of Land Clearing shal be in keeping with the standard and shall describe the requirements for application of the practice to achieve its intended purpose.

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SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

LAND SMOOTHING

Definition

Removing irregularities on the land surface by use of special equipment. Ordinarily, this does not require a complete grid survey. This includes operations ordinarily classed as rough grading. This does not include the "floating" done as a regular maintenance practice on irrigated land or the "planing" done as the final step in Irrigation Land Leveling or Drainage Land Grading.

Purposes

1. Improve surface drainage.
2. Provide for more effective use of precipitation.
3. Obtain uniform planting depths.
4. Provide for more uniform cultivation.
5. Improve equipment operation and efficiency.
6. Improve terrace alignment.
7. Facilitate contour cultivation.

Conditions Where Practice Applies

This practice applies on lands where depressions, mounds, old terraces, turn rows, and other surface irregularities interfere with the application of needed soil and water conservation and management practices.

It is limited to areas having adequate soil depths.

Design Criteria

The extent of rough grading required and tolerances of the finished smoothing job shall be in keeping with the requirements of the planned cropping system.

Plans and Specifications

Plans and specifications for application of Land Smoothing shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-466-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

MOLE DRAIN

Definition

An underground conduit formed by pulling a bullet-shaped cylinder through the soil.

Scope

This standard covers requirements of the site, the planning, and the installation of a system of unlined earthen channels and its facilitating and protective appurtenances.

Purpose

The objective of this practice is to establish a system of subsurface channels for removal of trapped surface and subsurface water from land where the use of buried drains is physically or economically impractical.

Conditions Where Practice Applies

Mole drains may be used in hay and cropland in highly cohesive or fibrous soils, free of stones, gravel or sand lenses where the area served is small and where an outlet is available or can be developed to provide continuously free outfall from the drains.

Design Criteria

Mole drains shall be installed in accordance with an approved plan, or as modified by an authorized technician at the site.

The location, grade, length of line, depth, spacing and size of drains, and the outlet protection for such drains shall meet requirements of Section 16, Soil Conservation Service National Engineering Handbook, or as modified by approved local drainage guides.

Plans and Specifications

Plans and specifications for installation of Mole Drains shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

OBSTRUCTION REMOVAL

Definition

Removing rock, stone fences, hedges, or fence rows and filling gullies or abandoned roads.

Purpose

To facilitate layout of crop rows, strip cropping, terracing, land smoothing, beautification, or road layout and construction for farms, ranches, and recreation areas.

Conditions Where Practice Applies

On land where existing obstructions interfere with development for its planned use.

Design Criteria

All rock piles, boulders, stone fences, hedge rows and similar obstructions that would interfere with planned use and development of the area shall be removed. All debris such as stone, stumps, slash and sterile soil material shall be disposed of so that it will not impede the application of subsequent components of the development work or cause damage to other areas. All required gully shaping shall be performed to the specified dimensions and grades. Gully fills shall be compacted to the required density.

Plans and Specifications

Plans and specifications for installation of Obstruction Removal measures shall be in keeping with the standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

OPEN CHANNEL

Definition

Constructing or improving a channel, either natural or artificial, in which water flows with a free surface.

Scope

This standard covers the construction of open channels or improvement of existing streams or ditches having a drainage area in excess of one square mile. It does not apply to Diversion (362), Drainage Field Ditch (590), Grassed Waterway or Outlet (412), Irrigation Canal or Lateral (320), or Irrigation Field Ditch (388).

Functional requirements for Drainage Main or Lateral (480), Floodwater Diversion (400), or Floodway (404) shall be in accord with the respective standard; but when the drainage area exceeds one square mile, design criteria regarding the channel stability and maintenance access shall be in accord with this standard for Open Channel.

Purpose

Open channels are constructed or improved and maintained to provide discharge capacity required for flood prevention, drainage, other authorized water management purposes, or any combination of these purposes.

Conditions Where Practice Applies

Provisions of this standard are applicable to all earth channel construction or improvement which includes flood prevention or drainage as a project purpose, along or in combination with other purposes, except as noted under "Scope" above.

Functional requirements for specific purposes such as flood prevention, drainage, etc., are in the standards covering those purposes. Stability requirements for all channels to which this standard is applicable, as defined in "Scope" above, shall be as specified herein.

An adequate outlet for the improved channel reach must be available for discharge by gravity flow or pumping.

Construction or other improvements of the channel must not cause significant erosion upstream or flooding and/or sediment deposition downstream.

Design Criteria

Plan

Channel construction or improvement shall be in accordance with Engineering Memorandum-72 and an approved plan developed for the site. Technical Release No. 25 shall be used for guidance in surveys, planning and site investigations. Those portions of TR 25 relating to detailed design procedures and design criteria shall be followed, using the procedure best adapted to site conditions.

The location and design of channels shall give careful consideration to the preservation of valuable fish and wildlife habitat and trees of significant value for wildlife food or shelter or for aesthetic purposes.

Where channel construction will adversely affect a significant fish or wildlife habitat, mitigation measures, acceptable to sponsors and concerned federal and state agencies, shall be included in the project.

Location

The alignment of channels shall not be changed to the extent that the stability of the channel or laterals thereto is endangered.

Channel Capacity

The capacity for open channels shall be determined by procedures applicable to the purposes to be served, and in accord with related Engineering Standards and Handbooks. The water surface profile or hydraulic grade line for design flow shall be determined in accord with guidelines for hydraulic design in Technical Release 25. The "n" value for aged channels, assuming good maintenance, shall be used in this computation. The required capacity may be established by consideration of volume-duration removal rates, peak flow or a combination of the two as determined by the topography, purpose of the channel, desired level of protection, and economic feasibility.

Hydraulic Requirements

Manning's formula shall be used to determine the velocities in the channels. The "n" values for use in this formula when designing channels to be constructed or improved shall be estimated using NEH-5, Sup. B. or NEH-16, Chapter 5.

The "Guide for Selecting Roughness Coefficient 'n' Values for Channels" compiled by Guy B. Fasken, Soil Conservation Service, USDA, Lincoln, Nebraska, 1963, and U. S. Geological Survey Water Supply Paper 1849, "Roughness Characteristics of Natural Channels" are useful guides in estimating "n" values of existing channels.

Channel Cross Section

The required channel cross section and grade are determined by the design capacity, the materials in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. Developments through which the channel is to be constructed must be considered in design of the channel section.

Channel Stability

Characteristics of a stable channel are:

1. It neither aggrades or degrades beyond tolerable limits.

2. The channel banks do not erode to the extent that the channel cross section is changed appreciably.

3. Excessive sediment bars do not develop.

4. Excessive erosion does not occur around culverts and bridges or elsewhere.

5. Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.

All channel construction and improvement shall be in accord with a design which can be expected to result in a stable channel which can be maintained at reasonable cost.

Technical Release No. 25 shall be used in determining the stability of proposed channel improvements using the method applicable to site conditions.

The effect of dikes or continuous spoil that confine the flow of water in channel floodways will be considered in determining bankfull stage and discharge.

Bankfull flow is defined as the flow in the channel which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cut through high ground, such as might result from realignment of the channel, should not be considered in determinations of bankfull flow.

Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bankfull flow, whichever is greater, using an "n" value based on the expected kind and density of vegetation and assuming good maintenance. In no case is it necessary to check channel stability for discharges greater than that from the 100-year frequency storm. The discharge used in stability analyses of channels having a controlled inflow shall be their design flow.

Channels also must be stable under conditions existing immediately after construction. For this stability analysis the velocity shall be calculated for the expected flow from a ten-year frequency storm on the watershed, or the bankfull flow, whichever is smaller, and the "n" value for the newly constructed channel shall be used. The "n" values of newly constructed channels in fine-grained soils and sands shall be determined in accord with NEH-5, Sup. B., and shall not exceed 0.025. The "n" value for channels to be improved by clearing and snagging only shall be determined by reaches according to the expected channel condition upon completion of the work.

In the humid sections of the United States, the allowable velocity in the newly constructed channel may be increased by a maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

1. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.

2. Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are known.

3. The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

Travelways for Maintenance

Travelways for maintenance shall be provided as a part of all channel improvement. A travelway shall be provided on each side of large channels if necessary for use of maintenance equipment. Travelways must be adequate for movement and operation of equipment required for maintenance of the channel. The travelway may be located adjacent to the channel on a berm or on the spread spoil. In some situations the channel itself may be used as the travelway.

Appurtenant Structures

The design of channels will provide for all structures required for the proper functioning of the channel and the laterals thereto and travelways for operation and maintenance. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design also is to provide for necessary flood gates, water level control devices, bays used in

connection with pumping plants and any other appurtenances affecting the functioning of channels and the attainment of the purposes for which they are built. If the improved channel bottom elevation is below the elevation of the bottom of a lateral channel at their junction to the extent that a recessed inlet is not feasible, the lateral channel must be stabilized by a sound durable structure.

The effect of channel improvements on existing culverts, bridges, buried cables, pipelines, irrigation flumes and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement.

Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge or state agency design requirements, whichever is greater. When the design discharge is based on storms which occur frequently, i.e., storms of one- or two-year frequency, it may be desirable to increase the capacity of culverts and bridges above the design discharge.

Disposition of Spoil

Spoil material resulting from clearing, grubbing and channel excavation shall be disposed of in a manner which will:

1. Minimize overbank wash.

2. Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed.

3. Not hinder the development of travelways for maintenance.

4. Leave the right of way in the best condition feasible, consistent with the project purposes, for productive use by the owner.

5. Improve the aesthetic appearance of the site to the extent feasible.

Plans and Specifications

Plans and specifications for construction of Open Channels shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

PIPELINE

Definition

Pipeline installed for the conveyance of water for livestock or recreational use.

Scope

This standard covers pipelines of less than 4 inches inside diameter installed for livestock watering or for use of recreational areas.

Purpose

To convey water from source of supply to points of use.

Conditions Where Practice Applies

Where conveyance of water in a closed conduit is desirable or necessary to conduct water from one point to another, conserve the supply, or for reasons of sanitation.

Design Criteria

Capacity

For livestock water the installation shall have the capacity to provide at least 12 gallons per head per day for beef cattle and horses, 25 gallons for dairy cattle, and 1-1/2 gallons for sheep and goats.

For recreational use the capacity shall be adequate for all planned uses of the water such as drinking, fire protection, showers, flush toilets and irrigation of landscaped areas.

Sanitary Protection

When water from the pipeline is likely to be used for human consumption the requirements of the State Health Department for material and installation must be met.

Pipe

Steel pipe shall meet the requirements of ASTM Specification A-120 or AWWA Specification C-202. Where local conditions are such as to require a coal-tar enamel protective coating for steel pipe, the coating shall meet the requirements of AWWA Specification C-203. Plastic pipe shall comply with ASTM Specifications D-2282, D-2239, or D-2241 respectively for Acrylonitrile-Butadiene-Styrene (ABS), Polyethylene (PE), and Polyvinyl Chloride (PVC).

Provisions for Draining

Valves or unions shall be installed at low points in the pipeline so that it may be drained as needed.

Vents

For design velocities lower than 8 feet per second some provisions for removing the air should be included in the design. If parts of the line are above the hydraulic gradient, periodic use of an air pump will probably be required.

Joints

Watertight joints having a strength equal to that of the pipe shall be used. Couplers must be of similar material or completely insulated.

Plans and Specifications

Plans and specifications for installation of Pipelines shall be in keeping with this standard and shall describe the requirements for application for the practice to achieve its intended purpose. See page S-516-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

POND

Definition

A water impoundment made by constructing a dam or embankment, or by excavating a pit or "dugout."

Ponds constructed by the first of these methods are referred to hereinafter as "Embankment Ponds" and those constructed by the latter method as "Excavated Ponds." Ponds resulting from both excavation and embankment are classified as "Embankment Ponds" where the depth of water impounded against the embankment at spillway elevation is 3 feet or more.

Purpose

Ponds are constructed to provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses.

Scope

This standard establishes the minimum acceptable quality for the design and construction of class (a) ponds located in predominantly rural or agricultural areas when:

1. Failure of the structure would not result in loss of life; in damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.

2. The product of the storage times the effective height of the dam does not exceed 3,000 where the storage is defined as the original volume (acre-feet) in the reservoir at the elevation of the crest of the emergency spillway and the effective height of the dam is defined as the difference in elevation (feet) between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam.

3. The vertical distance between the lowest point along the centerline of the dam and the crest of the emergency spillway does not exceed 20 feet.

Conditions Where Practice Applies

Site Conditions
Site conditions shall be such that the peak rate of runoff that can be expected to occur once in 25 years can be safely passed through (1) a natural or constructed emergency spillway, or (2) a combination of a principal structural spillway and an emergency spillway, except that a storm of 10-year frequency may be used for drainage areas less than 20 acres in size.

Drainage Area
The drainage area above the pond must be protected against erosion to the extent that expected normal sedimentation will not shorten the planned effective life of the structure.

The drainage area shall be large enough that surface runoff, together with groundwater flow, will maintain an adequate supply of water in the pond.

Depth
The topography and soils of the site shall permit storage of water at a depth and volume which will insure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses.

Foundation
The area on which a dam is to be placed shall consist of material that has sufficient bearing strength to support the dam without excessive consolidation. The foundation must consist of or be underlain by relatively impervious material which will prevent excess passage of water.

Reservoir Area
Where surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses, or shall be of a type that sealing is practicable.

Embankment Ponds

Design Criteria

Foundation Cutoff
A cutoff of relatively impervious material shall be provided under the dam, except in those cases where a layer of such material exists at the surface of the foundation. The layer of impervious material shall be thick enough to provide stability. The cutoff shall extend along the centerline of the dam and its abutments as required and be deep enough to extend into a relatively impervious layer.

The cutoff trench shall have a bottom width and side slopes adequate to accommodate the equipment used for excavation, backfill, and compaction operations.

Earth Embankment

Top width - The minimum top width of the dam shall be:

Height of Dam	Top Width
10 feet or less	6 feet
11 - 14 feet	8 feet
15 - 20 feet	9 feet

Side slopes - The combined upstream and downstream side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical with neither slope steeper than 2:1.

Freeboard - The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the emergency spillway flowing at design depth.

Allowance for settlement - The design height of the dam shall be increased by the amount needed to insure that the design top elevation will be maintained after all settlement has taken place. This increase shall not be less than 5 percent.

Pipe conduits

A pipe conduit, with needed appurtenances, shall be placed under or through the dam except where the rate and duration of flow can be handled safely by a vegetated earth spillway or a rock or concrete spillway is available.

Size - The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows without flow through the earth spillways. The minimum diameter of the pipe shall be 4 inches.

Where the pipe conduit diameter is 10 inches or greater its design discharge may be considered in calculating the peak-outflow rate through the emergency spillway.

Crest elevation of inlet - The crest elevation of the inlet or riser shall be at least 0.5 foot below the crest elevation of the earth spillway. Where the pipe conduit is designed as a principal spillway, the crest elevation of the inlet or riser shall be such that full flow will be generated in the barrel before there is discharge through the earth spillway.

Pipe - The following materials are acceptable: Cast-iron, wrought-iron, steel, corrugated metal, asbestos-cement, concrete, and rubber-gasket vitrified clay. All pipe joints shall be made watertight by the use of watertight couplings or gaskets or by welding or caulking. Asbestos-cement, concrete, and vitrified clay pipe shall be laid in a concrete bedding. All pipe shall be capable of withstanding the external loading.

Anti-seep collars - Anti-seep collars shall be installed around the pipe conduit within the normal saturation zone when any of the following conditions exist:

1. The settled height of the dam exceeds 15 feet.

2. The conduit is of smooth pipe larger than 8 inches in diameter.

3. The conduit is of corrugated metal pipe larger than 12 inches in diameter.

The anti-seep collars and their connections to the pipe shall be watertight. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe.

Trash guards - Where necessary to prevent clogging of the conduit, an approved type of trash guard shall be installed at the inlet or riser.

Drain pipe - A drain pipe with a suitable valve at its upper end shall be provided where needed for proper pond management, or where required by state law. The pipe conduit may be used as a drain when so located as to accomplish this function.

Water supply pipes - Supply pipes to watering troughs and other appurtenances shall have a minimum inside diameter of 1 1/4 inches.

Earth Spillways

Capacity - The minimum capacity of natural or constructed emergency spillways shall be that required to pass the peak outflow expected from a 25-year-frequency storm, less any reduction creditable to conduits and detention storage, except that a storm of 10-year frequency may be considered for drainage areas of 20 acres or less. Emergency spillways shall be designed for safe velocities through the control section and a reasonable distance below.

Cross section - Constructed earth spillways shall be trapezoidal and will be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed.

Component parts - Constructed spillways shall have an inlet channel and an exit channel.

Upstream from the control section the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing topography.

The grade of the exit channel of a constructed spillway shall fall within the range established by discharge requirements and permissible velocities. It shall terminate at a point well removed from any part of the embankment where the design flow may be discharged without damage to the earth embankment.

Excavated Ponds

Design Criteria

Side slopes - Side slopes of excavated ponds shall be such that they will be stable and shall not be steeper than 1 horizontal to 1 vertical. Where livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a uniform slope no steeper than 4 horizontal to 1 vertical.

Inlet protection - Where surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Placement of excavated material - The material excavated from the pond shall be placed in one of the following ways so that its weight will not endanger the stability of the pond side slopes and where it will not be washed back into the pond by rainfall:

1. Uniformly spread to a height not exceeding 3 feet with the top graded to a continuous slope away from the pond.

2. Uniformly placed or shaped reasonably well with side slopes assuming a natural angle of repose for the excavated material behind a berm width equal to the depth of the pond but not less than 12 feet.

3. Used for low embankment and leveling.

4. Hauled away.

Plans and Specifications

Plans and specifications for installation of ponds shall be in keeping with this standard and shall describe the requirements for application for the practice to achieve its intended purpose. See page S-378-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

POND SEALING OR LINING
Flexible Membrane

Definition

Installing fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

Scope

This standard applies to the use of flexible membrane linings made of plastic, rubber, and similar material.

Conditions Where Practice Applies

This practice applies where water loss from a pond through leakage is or will be of such proportion as to prevent the pond from fulfilling its planned purposes, or where leakage will damage land, crops, or cause waste of water, and environmental problems.

Design Criteria

Ponds to be lined shall be constructed to meet the Soil Conservation Service Engineering Standard and Specifications for Pond, Irrigation Pit or Regulating Reservoir, Irrigation Storage Reservoir, Wildlife Watering Facility, Disposal Lagoons, or Holding Ponds and Tanks as appropriate.

The flexible membranes to be used as linings shall be suitably constructed of high quality ingredients and shall be certified by the manufacturer to be suitable for this use. Pigmented polyvinyl or polyethylene plastics, rubber, and similar materials that are highly resistant to bacteriological deterioration will be acceptable base materials.

If the membranes are reinforced, an inorganic reinforcing material must be used.

All plastic membranes should have a cover of earth or earth and gravel not less than 6 inches thick. Rubber membranes need not be covered except in areas subject to travel by livestock. In these areas, a minimum cover of 9 inches shall be used on all types of flexible membranes. The bottom 3 inches of cover should not be coarser than silty sand.

All membranes shall be of a quality that meets or exceeds the attached materials specifications for Polyvinyl Chloride, Polyethylene and Rubber--Tables I, II, III, and IV. Minimum nominal thickness shall be:

Soil Material Not Coarser than:	Plastic Sheeting	Rubber Sheeting	
		Nylon Reinforced	Unreinforced
Sands; SM, SP, SW	8 mil.	20 mil.	30 mil.
Gravels; GC, GM, GP, GW	12 mil.	30 mil.	30 mil.

Plans and Specifications

Plans and specifications for installation of Pond Sealing or Lining, Flexible Membrane shall be in keeping with this standard and shall describe the requirements for application for the practice to achieve its intended purpose. See page S-521-A-1 for items to be considered in development of specifications.

TABLE I

POLYVINYL CHLORIDE PLASTIC SHEETING

TEST DESCRIPTION	REQUIREMENTS	TEST METHOD
Tensile Strength, Each Direction Minimum psi	2000	ASTM-D-882
Elongation, Each Direction, Minimum %	250	ASTM-D-882 (Method A)
Volatility, % Maximum Loss	0.7	ASTM-D-1203
Water Extraction, Maximum % Weight Loss	0.5	ASTM-D-1239
Tear Resistance (Elmendorf) Each Direction - Minimum Grams/Mil	160	ASTM-D-1922
Compost Resistance		Page S-521-A-2
Tensile Retained, Each Direction Minimum %	95	
Elongation retained, Each Direction Minimum %	80	
Commercial Field Splice Strength Shear Force, % of Minimum Tensile	80	Commercial field splice, one inch wide strip, pulled in shear at 10"/ minute, after 7 days cure at room temperature

TABLE II

UNREINFORCED RUBBER SHEETING

TEST DESCRIPTION	REQUIREMENTS TYPE "A"	TYPE "B"	TEST METHOD
Tensile Strength, Minimum psi=	1200	1200	ASTM-D-412
Modulus at 300% Elongation, Minimum psi	600	600	ASTM-D-412
Ultimate Elongation, Percent Minimum	300	300	ASTM-D-412
Shore "A" Hardness	60±10	60±10	ASTM-D-2240
Ozone Resistance - Procedure "A"			ASTM-D-1149
No cracks - 50 pphm - 100°F - 20% Elongation	7 days		ASTM-D-518
No cracks - 50 pphm - 100°F 100% Elongation		14 days	
Heat Aging - 7 days at 212°F			ASTM-D-573
Tensile strength retained, % of original	75	75	
Elongation retained, % of original	75	75	
Water Vapor Permeability - at 80°F Perm-mils, maximum	.002	.05	ASTM-E-96 (Procedure BW)
Tear Resistance, lbs. per inch., minimum	150	150	ASTM-D-624 Die "B"
Dimensional Stability, 7 days at 212°F, % of change in length or width	±0.5	±0.5	
Commercial Field Splice Strength Shear force, % of minimum tensile	60	60	Commercial Field Splice, one inch wide strip pulled in shear at 10" per minute, after 7 days cure at room temp.

NOTE: Type "A" sheeting is recommended for general purpose outdoor usage.

Type "B" material is suggested where an extreme outdoor environment requires a highly weatherable lining.

TABLE III

NYLON REINFORCED RUBBER SHEETING

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS UP TO 20 MILS THICKNESS	REQUIREMENTS 20 MILS THICK & GREATER	TEST METHOD
Breaking Strength,			
Minimum lbs./inch			ASTM-D-751
Warp Direction	75	100	
Fill Direction	75	100	
Ultimate Elongation,			
% Maximum			ASTM-D-751
Warp Direction	30	30	
Fill Direction	30	30	
Ozone Resistance - Procedure "B"			ASTM-D-1149
50 pphm - 100°F	7 days	7 days	ASTM-D-518
Hydrostatic Strength After Ozone Exposure (7 days)			Fed. Spec.
(Mullen) % Retained	100	100	CCC-T-191b, Method 5512, ASTM-D-518
Heat Aging - 7 days at 212°F			ASTM-D-573
Tensile strength retained, % of original	90	90	
Elongation retained, % of orig.	90	90	
Tear Resistance - Minimum			ASTM-D-751
Warp or Fill Direction,			(Tongue)
Lbs.	8	8	
Hydrostatic Burst (Mullen), psi Minimum	100	175	ASTM-D-751
Dimensional Stability, 7 days at 212°F			-*-
% change in length or width	± 1.0	± 1.0	

*One foot square sample, 10" bench marks in warp and fill direction, placed on Aluminum or Stainless plate in changing air over.

TABLE III (CONTINUED)

NYLON REINFORCED RUBBER SHEETING

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS UP TO 20 MILS THICKNESS	20 MILS THICK & GREATER	TEST METHOD
Low Temperature Flexibility (Optional) No cracking or flaking	-40°F	-40°F	Fed. Spec. CCC-T-191b Method 5874
Commercial Field Splice Strength Shear Force, % of Minimum Tensile	75	75	Commercial field splice one inch wide strip, pulled in shear at 10"/minute, after 7 days cure at room temperature

TABLE IV

POLYETHYLENE AND ETHYLENE CO-POLYMER PLASTIC FILM

For Canal Lining

TEST DESCRIPTION	REQUIREMENTS TYPE I POLYETHYLENE	REQUIREMENTS TYPE II CO-POLYMER	TEST METHOD
Tensile Strength Each Direction, Minimum Avg. psi	1800	2000	ASTM-D-882 Method "A"
Ultimate Elongation Each Direction, Minimum Avg. %	500	500	ASTM-D-882 Method "A"
Impact Resistance Minimum Average, Grams/Mil	45	65	ASTM-D-1709 Method "B"
Water Vapor Permeability - Perm-Mils	0.7	1.5	ASTM-E-96
Tear Resistance (Elmendorf) Each Direction, Minimum Grams/Mil	80	80	ASTM-D-1922
Compost Resistance			
Tensile retained, Each Direction, Minimum %	95	95	Page S-521-A-2
Elongation retained, Each Direction, Minimum %	80	80	
Luminus Transmittance % Maximum	1.0	1.0	CS-238, paragraph 6.8

( ) = recommendations, ASAE, December 1969 draft of Stds.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

POND SEALING OR LINING
Soil Dispersant

Definition

Installing fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

Conditions Where Practice Applies

This practice applies where water loss from a pond through leakage is, or will be, of such proportion as to prevent the pond from fulfilling its planned purpose or where leakage will damage land or crops or will cause waste of water.

Design Criteria

Ponds to be sealed shall be constructed to meet Soil Conservation Service Engineering Standard and Specifications for Farm Pond, Irrigation Pit or Regulating Reservoir, Irrigation Storage Reservoir, Wildlife Watering Facility, Disposal Lagoons, or Holding Ponds and Tanks as appropriate.

Soil Properties

For chemical sealing, soils shall have properties approximating the following:

At least 50 percent finer than 0.074 mm diameter (#200 Sieve)

At least 15 percent finer than 0.002 mm diameter

Less than 0.50 percent soluble salts (based on dry soil weight)

Dispersants

Tetrasodium pyrophosphate (TSPP) and sodium tripolyphosphate (STPP) should be used in preference to other polyphosphate salts. Commercial phosphatic fertilizer is not acceptable. Soda ash, tech grade, 99-100 percent sodium carbonate may be used.

These dispersants should be finely granular with 95 percent passing a number 30 sieve and less than 5 percent passing a number 100 sieve.

Standard commercial sodium chloride is satisfactory in the granulated form normally available.

Other dispersants may be used in the form found by local experience to be satisfactory.

Rate of Application
The rate of application and the kind of dispersant to use shall be based on laboratory tests unless sufficient data are available on the field performance of previously tested soils and their similarity texturally and chemically to the soil to be sealed.

In the absence of laboratory tests on the soils to be sealed, the minimum application shall be:

Sodium Polyphosphate - 5 to 10 lbs./100 sq. ft.

Sodium Chloride - 20 to 33 lbs./100 sq. ft.

Soda Ash - 10 to 20 lbs./100 sq. ft.

Other - as found by local experience to be adequate

Thickness of Treated Blanket
The finished treated blanket shall be at least 6 inches thick for water depths up to eight feet. For greater depths of water, the blanket thickness shall be twelve inches and treated in two 6-inch lifts. A minimum thickness of 12 inches is recommended for all areas in the vertical range of water surface fluctuation.

There shall be at least 2 feet of fine-grained soil over fractured rock outcrops or other highly permeable material in addition to the treated blanket.

Plans and Specifications

Plans and specifications for installation of Pond Sealing or Lining - Soil Dispersants shall be in keeping with this standard and shall describe the requirements for application for the practice to achieve its intended purpose. See page S-521-B-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

POND SEALING OR LINING
Bentonite

Definition

Installing fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

Scope

This standard covers the sealing of ponds with bentonite or similar high swell clay materials.

Conditions Where Practice Applies

Where water loss from a pond through leakage is or will be of such proportion as to prevent the pond from fulfilling its planned purpose, or where leakage will damage land or crops.

Design Criteria

Ponds to be sealed shall be constructed to meet Soil Conservation Service Engineering Standards and Specifications for Pond, Irrigation Pit or Regulating Reservoir, Irrigation Storage Reservoir, Wildlife Watering Facility, Disposal Lagoons, or Holding Ponds and Tanks as appropriate.

Soil Properties
Sealing with bentonite or similar materials is more applicable on coarse-grained soils where more than half of the material is larger than the No. 200 sieve size.

Rate of Application
The rate of application shall be based on laboratory tests unless sufficient data are available on the field performance of previously tested soils with a similarity, texturally and chemically, to the soils to be sealed.

In the absence of laboratory tests or field performance data on the soils to be sealed, the minimum application shall be:

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Pervious Soil	Application Method	Application Rate
clay	pure membrane or mixed layer	1.0 - 1.5 lb./sq. ft.
sandy silt	mixed layer	1.0 - 1.5 lb./sq. ft.
silty sand	mixed layer	1.5 - 2.0 lb./sq. ft.
clean sand	mixed layer	2.0 - 2.5 lb./sq. ft.
open rock or gravel	clay or sand mixed layer	2.5 - 3.0 lb./sq. ft.

Thickness of Treated Blanket

The minimum thickness of the finished treated blanket shall be 4 inches for water depths up to eight feet. Additional thickness shall be provided for greater water depths, for pond areas exposed to drying, and for areas subject to wave action.

Plans and Specifications

Plans and specifications for installation of Pond Sealing or Lining - Bentonite shall be in keeping with this standard and shall describe the requirements for application for the practice to achieve its intended purpose. See page S-521-C-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

POND SEALING OR LINING
Cationic Emulsion - Water-Borne Sealant

Definition

Installing a fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

Conditions Where Practice Applies

Where water loss from a pond through leakage is, or will be, of such proportion as to prevent the pond from fulfilling its planned purpose or where leakage will damage land or crops or will cause waste of water, and where seepage reduction of 70 to 95 percent will adequately solve the leakage problem.

Design Criteria

Ponds to be sealed shall be constructed to meet Soil Conservation Service Engineering Standards and Specifications for Pond, Irrigation Pit or Regulating Reservoir, Irrigation Storage Reservoir, Wildlife Watering Facility, Disposal Lagoons, or Holding Ponds and Tanks as appropriate.

Soil Properties
For electrochemical sealing, soils (in the surface 2") shall have properties approximating the U.S.D.A. textural soil classification for:

1. Very fine sands, fine sands, medium sands, coarse sands, and very coarse sands.

2. Non-expansive loamy sands and sandy loams.

Where the soil is relatively uniform throughout the entire pond, the seepage rate before sealing should exceed one foot per day, measured vertically. Where isolated sections within an area are suspected to cause most of the seepage loss, the seepage rate in these areas before sealing should exceed one foot per day.

Sealant Specifications
The sealant should be a stable o/w emulsion of suitable bituminous, resinous or polymeric bases, having infinite dilutability and good stability after dilution in all fresh waters of any native hardness. (The emulsion must be infinitely dilutable in the water to be treated

without causing the asphalt to break.) Air and water temperature should be above 40°F. and discrete sealant droplets should be able to coalesce at 40°F. or above as they deposit on underlying soil.

The sealant must conform to the following applicable ASTM specifications and testing procedures:

Cationic Emulsified Asphalt Specification

ASTM Designation: D2397
(to be used in part as applicable to Soil Sealant)

	Cationic Soil Sealant	
	Minimum	Maximum
Viscosity (Saybolt Furol), 122° (50°C.), sec.	20	100
Settlement, 5 days, percent		5
Particle Charge Test	Positive	
Sieve Test, Percent		0.10
*Distillation:		
Oil Distillate, by volume of emulsion, percent		3
Residue, percent	60	
Test on Distillation Residue:		
Penetration, 77°F. (25°C.), 100 g, 5 sec.	100	200
Ductility, 77°F. (25°C.), cm	40	
Soluble in carbon di sulfide, percent	98	

(*Evaporation test may be used in place of distillation for percent residue and penetration.)

Testing Procedures

Viscosity	ASTM D-244-65
Settlement	" " "
Particle Charge	" " "
Sieve	" " "
Distillation	" " "
Evaporation	" " "
Penetration	" D5-65
Ductility	" D-113-44
Solubility	" D-4-52

Rate of Application

The minimum rate of application shall be based on small scale field tests with infiltration cylinders unless sufficient data are available on the field performance of previously tested soils and their similarity texturally and chemically to the soil to be sealed.

In the absence of field test results on the soils to be sealed, the minimum application shall be 1 gallon per square yard.

Plans and Specifications

Plans and specifications for installation of Pond Sealing or Lining - Water-Borne Sealant, shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-521-D-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

PUMPED WELL DRAIN

Definition

A well sunk into an aquifer from which water is pumped to lower the prevailing water table.

Scope

This standard applies to drilled or driven wells used for pumping groundwater to lower the water table level in a given area. It does not apply to Vertical Drains, sometimes called drainage wells, constructed for the purpose of discharging drain effluent into porous underground formations. Pumps, motors, or other appurtenances needed to pump water from the aquifers are not included.

Test wells established for investigational purposes prior to the installation of a permanent well are considered temporary and are not covered by this standard.

Purpose

Pumped well drains are installed to provide subsurface drainage by lowering the prevailing water table to a level which will provide maximum benefits to crops or soils by removal of excess groundwater and/or salts from the soil profile.

Conditions Where Practice Applies

This practice applies to agricultural lands subject to a high water table and in need of subsurface drainage, where pumping from wells is feasible and is the most economical method of drainage. This requires a permeable aquifer at a depth and of such thickness and magnitude that, when pumped, will lower the water table to the desired degree.

An adequate outlet for the pumped drain water, considering its quantity and quality, must be available.

Pumping of groundwater in the quantity necessary to provide adequate drainage must conform with state statutes and regulations.

Design Criteria

General
The criteria for design given in Tentative American Society of Agricultural Engineers Recommendations, ASAE R 283(T), "Designing and Constructing Water Wells for Irrigation," provides good guidance for well design and construction.

Quantity of Water
The amount of groundwater to be pumped from the well or wells will be that amount required to provide the desired drawdown in the area being drained.

Multiple Well Drains
Where more than one well is used in the system, the cones of depression developed by each shall overlap to such an extent that the points of least drawdown will be at the desired level after drainage.

Well Depth and Diameter
The well depth and diameter shall be such that the amount of water that can be drawn from the aquifer is sufficient to maintain the desired drawdown throughout the crop growing season. Gravel envelopes may be used in conjunction with screens to serve as a filter and to increase the effective diameter of the well.

Casing
All wells shall be cased with steel, concrete, wrought iron, copper, plastic, asbestos-cement, or other material of adequate strength and durability. The casing shall have a diameter that is adequate to accommodate the required pumping equipment.

Screens
All wells shall be equipped with manufactured screen sections, well points, shop-perforated metal casing sections, or field perforated sections meeting the criteria stated below.

The screen openings for aquifer material of near uniform size shall be slightly smaller than the average diameter of the aquifer material. For graded aquifer materials (of non-uniform gradation) the screen openings shall be such that 25 to 40 percent of the aquifer material is larger than the screen opening.

A sufficient length of screen shall be provided to maintain the entrance velocity of water into the well at an acceptable level, preferably less than one-tenth foot per second.

The position of the screen in the well will be governed by the depth of the aquifer below the ground surface and the thickness of aquifer to be penetrated by the well.

Quality of Water
Where the water from the well drain is to be used for human consumption it shall meet all requirements of the State Health Department or other state agency having jurisdiction. If the water is high in salt content or is not potable, means of disposal shall be planned and installed concurrently with the installation of the well, which will not adversely affect potable water sources and the environment.

Plans and Specifications

Plans and specifications for construction of Pumped Well Drains shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose. See page S-532-1 for additional items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

PUMPING PLANT FOR WATER CONTROL

Definition

A pumping facility installed for removing excess surface or ground water from lowlands, or for pumping from wells, ponds, streams, and other sources.

Purpose

To provide a dependable and economical facility to control the water level on wet lands or to provide a water supply for such purposes as irrigation, recreation, livestock, or wildlife.

Conditions Where Practice Applies

Wherever water must be pumped to accomplish the conservation objective.

Design Criteria

The efficiency of units, type of power, quality of building, automation and accessories installed, shall be in keeping with the value and importance of the system, needs and desires of the sponsoring group or individual, and shall accomplish the conservation objectives.

Pump Requirements

The capacities, range of operating lifts, and general class and efficiency of equipment shall be determined from appropriate technical studies. The size and number of pumps and their performance requirements shall be determined based on the conservation requirements of the system. The total head shall be determined for critical operating conditions taking into account all hydraulic losses. Automatic controls shall be included in the plans as required.

Power Units

The power units shall be selected on the basis of costs, operating conditions, conservation needs and objectives, including need for automation. The power unit shall be matched to the pump and be capable of operating the pump effectively within the range of operating conditions. The horsepower requirements, pump efficiency, and the total head on the pump shall be computed.

Suction and Discharge Pipes
The sizes of suction and discharge pipes shall be based on studies of efficiencies and effects on costs and operations. The arrangement and length of discharge pipe shall be based on need for recovery of head through syphonic action, and for delivery of water in keeping with conservation objective. Gates, valves, pipe connections, discharge bays, and other protective works shall be installed as needed for satisfactory plant operation.

Building and Accessories
The design of the plant and associated housing, if required, shall consider the need for protecting equipment from the elements, malicious damage, and fire, and the need for equipment maintenance and repairs. The appearance of the plant shall be in keeping with its surroundings, importance and value.

The foundations shall be designed to safely support the loads imposed. Sheet piling or other measures shall be used as required to prevent piping beneath the foundation.

Pumps may be mounted in the open, on piling or in a well or pit.

Suction bays (or sumps) shall be designed to conform to the hydraulic characteristics established by the pump manufacturer.

The discharge bay or connection with distribution system shall be ample to meet hydraulic and structural requirements. Provisions for repair or removal of pumps and engines shall be provided. Trash racks shall be provided as needed to exclude debris and trash from the pump.

All structural features and equipment shall provide adequate safety features to protect workers and the public against injury.

Plans and Specifications

Plans and specifications for construction of Pumping Plants for Water Control shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

RECREATION LAND GRADING AND SHAPING

Definition

Altering the surface of land to meet the requirements of recreation facilities.

Scope

This standard applies where modification of the land surface is required to permit installation of recreation facilities.

Conditions Where Practice Applies

On sites where surface irregularities, slopes, kinds of soil, obstructions or wetness interfere with planned recreational use; or where such use requires designed land surfaces.

Special attention will be given to maintaining or improving habitat for fish and wildlife where applicable.

Design Criteria

Shaping
Where shaping only is required the cuts and fills may be estimated by observation or with only a minimum amount of work with an engineer's level.

Grading
Where grading to uniform surfaces is required the design shall be based on a complete topographic or grid survey.

Erosion Control and Drainage
The requirements for erosion control and surface and subsurface drainage shall be included in the plan.

Specific Uses
Grading and shaping for specific uses, such as athletic fields, shall be in accord with the requirements of the use involved.

Plans and Specifications

Plans and specifications for installation of Recreation Land Grading and Shaping shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-566-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

RECREATION TRAIL AND WALKWAY

Definition

A pathway prepared especially for pedestrian, equestrian, and cycle travel.

Scope

This standard applies to walkways and trails constructed within recreation and scenic areas.

Purpose

To provide recreation area users with travel routes for activities such as walking, sightseeing, horseback riding and bicycling.

Conditions Where Practice Applies

This practice applies to lands where prepared paths, trails, and walkways are needed for effective and safe use of the recreation resources.

Design Criteria

Grade
Sustained grades shall be that dictated by good judgment for the purpose intended, considering the topography.

Width
Generally the minimum tread width shall be 3 feet. The width in cuts for pedestrian trails on sidehill sections may be reduced to 2 feet where a greater width would increase the cost materially.

Side Slopes
Cut and fill slopes shall be such as to be stable for the soil or soil material.

Drainage
Adequate surface drainage shall be provided. A raised or elevated trail or walkway may be required for wet sites that cannot be drained.

Erosion Control
The plans shall include provisions for control of erosion on all disturbed areas and at all culverts and other drainage structures.

Bridges
Bridges shall be designed for the maximum expected loading.

Surfacing
Where surfacing is required for a firm trail the surfacing material may be pit or creek-run gravel, concrete, asphalt, or other material that will withstand the traffic and the elements at the site.

Safety
Due consideration shall be given to safety. Protection from slides and falling rocks shall be provided if needed. Adequate directional and warning signs, handrails, bridges, and culverts shall be placed as dictated by the site and intended use.

General
Equestrian and pedestrian trails may vary from specific grades, widths, and clearing requirements when so dictated by location and topography.

Plans and Specifications

Plans and specifications for installation of Recreation Trail and Walkway shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See pg. S-568-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

REGULATING WATER IN DRAINAGE SYSTEMS

Definition

Controlling the removal of surface or subsurface runoff, primarily through the operation of water control structures.

Scope

This standard is applicable to the regulation of surface and subsurface water outflow through drainage systems. This frequently involves other allied reportable practices, such as are listed under Design Criteria for this standard.

Purpose

The purpose of the practice is to conserve surface or subsurface water by controlling the outflow from drainage systems to maintain optimum soil moisture conditions. Such conservation of water will make it possible to:

1. Establish and encourage the growth of desired field or forest plants.

2. Reduce subsidence and wind erosion of organic soils.

3. Hold water in channels in forest areas to act as ground-fire breaks and provide drinking water for wildlife and a resting and feeding place for waterfowl.

Conditions Where Practice Applies

This practice applies to areas needing drainage during certain periods and where it is advantageous to limit the outflow or pumping rate at other times. This practice is applicable especially in organic soils and in highly permeable soils of low available water holding capacity.

Regulation of outflow should be undertaken only when soil water salinity or alkalinity is not likely to be a problem.

Design Criteria

The water management system must have the depth, spacing, and capacity to provide the necessary drainage relief for the plants when controls are open. Control of outflow shall be by structures or

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pumps capable of removing the design flow or if regulating water stages in the drainage system. The outflow controls shall be related to the amount of water available and the degree of control necessary for soil and plant requirements.

The design of related water management practices such as Drainage Main or Lateral; Irrigation System, Surface and Subsurface; Pumping Plant for Water Control; Structure for Water Control; Dike; Drainage Land Grading; and Land Smoothing will need to be coordinated with this practice for it to achieve its intended purpose.

For crops which are highly sensitive to both excessive and inadequate soil water conditions, the field surfaces must be smooth and the distance between the soil water level and the ground surface must be as uniform as practical. Fields shall be smoothed or graded as required to achieve this uniformity. Structures and pumps shall be located where they will be accessible and subject to convenient control.

Plan of Operation

A plan of operation shall be developed for the system which will insure that the objectives are met. The plan of operation shall include such information as time and stage to hold water in ditches, pumping schedules, and coordination of water management operations in the system with rainfall, season, and crop and soil moisture needs.

Plans and Specifications

Plans and specifications for Regulating Water in Drainage Systems shall be in keeping with this standard and shall describe the requirements for proper installation and operation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

ROCK BARRIER

Definition

A rock retaining wall constructed across the slope to form and support a bench terrace which will control the flow of water and check erosion on sloping land.

Scope

This standard applies to all rock barriers of heights 6 feet or less and on land slopes up to 50 percent.

Purpose

To stabilize steeply sloping land so that it can be farmed with a minimum of soil loss.

Conditions Where Practice Applies

Rock barriers are applicable to land suitable for cultivation where soil depth is adequate for benching and where the effectiveness of less intensive measures for soil and water conservation would be questionable. Suitable natural outlets or satisfactory sites for constructing outlets must be available.

Design Criteria

Grade
The top of the rock barrier may be level or have a grade toward the outlet. Maximum grade shall be 0.5 percent.

Cross Slope
The bench between barriers shall have a negative slope from the top of one barrier to the toe of the up-slope barrier. Cross slopes shall have a grade of 1.0 to 3.0 percent.

Surface Drain
Surface drainage shall be provided by a longitudinal ditch not less than 0.5 square feet in area along the toe of the up-slope barrier.

Height
The height of the rock barrier shall not exceed 6 feet.

Base Width
The minimum base width shall be 18 inches plus 1.5 inches for each 0.5 foot of height in excess of 2.5 feet. The exposed face of the barrier shall have a batter of 3 inches per foot of height.

Vertical Interval
Vertical interval between adjacent benches shall not exceed 5 feet.

Horizontal Interval
The minimum horizontal distance between barriers shall be 10 feet.

Plans and Specifications

Plans and specifications for installation of Rock Barriers shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-555-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

ROW ARRANGEMENT

Definition

The establishment of a system of crop rows on planned grades and lengths primarily to facilitate drainage and erosion control.

Scope

This standard applies to row arrangement on all cropland where crops are grown in rows and a problem of inadequate drainage, soil erosion, or inadequate utilization of available rainfall or irrigation water exists.

Purpose

To establish the crop rows in direction, grade, and length so as to provide adequate drainage and erosion control, and which will permit optimum utilization of rainfall and irrigation water.

Conditions Where Practice Applies

Proper row arrangement is applicable:

1. As a part of a surface drainage system for a field where the rows are planned to carry excess water to drainage field ditches.

2. To facilitate optimum utilization of water in graded furrow irrigation systems.

3. In dryland areas where it is necessary to control the grade of rows in order to utilize available rainfall more fully.

4. On sloping land, with or without other conservation practices, where control of length, grade, and direction of rows will contribute to reduction of soil erosion.

Design Criteria

General

Row arrangement.shall facilitate the use of applicable farm machinery within the field.

Surface Drainage

As part of a surface drainage system, row arrangement shall:

1. Conform with the Drainage part of the Technical Guide for the area regarding grade and length.

2. Facilitate flow of excess water from the field into the drainage field ditches.

Furrow Irrigation

As part of a furrow irrigation system, row arrangement shall:

1. Conform with the Irrigation Guide for the area regarding grade and length.

2. Facilitate irrigation water management within the field.

Erosion Control and Water Conservation

As part of an erosion control and/or water conservation system for a field, row arrangement shall:

1. Conform with the Technical Guide for the area for the particular practice for which the row arrangement is a facilitating measure.

2. Conform with the grade and length requirements for Terraces where row arrangement is used without another engineering practice.

Plans and Specifications

Plans and specifications for Row Arrangement shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

SPOILBANK SPREADING

Definition

Disposing of excavated materials from a drainage ditch or irrigation canal by spreading the surplus over adjacent land.

Scope

This standard covers the handling of spoil, either by placement in surface depressions, by shaping, or by spreading over the surface of banks and adjacent lands along the ditch or canal from which the spoil was removed.

Purpose

The principal objectives of this practice are to permit agricultural or other use of land occupied by spoil, to facilitate establishment and control of vegetation along banks, to provide a travelway along banks for maintenance, or to provide borrow for land grading, leveling, or smoothing of adjoining land.

Conditions Where Practice Applies

This practice applies to sites where spoil material is available from the excavation of channels, drainage ditches or irrigation canals and where it is desirable and economically feasible to achieve one or more of the conservation purposes listed above.

Design Criteria

Spoil shall be spread continuously over a designated area in accordance with an approved plan, or as modified by a technician at the site where authorized in the contract or otherwise feasible. Provisions shall be made for the diversion or safe passage of surface water concentrating on the landside of the spoilbank.

The spoil shall be placed so as not to endanger the stability of the ditch bank and shall not exceed 3 feet in height above the natural ground surface, except by special design. The finished surface shall slope away from the edge of the channel or berm in so far as feasible.

Surfaces of spoil shall not be steeper than 4 horizontal to 1 vertical on the landside, and 3 horizontal to 1 vertical on channel side if a berm is established. If the spoil is spread to the edge of the

channel, the channel side slope of the spoil shall be shaped to join the side slope of the ditch bank so loose spoil will not roll or wash into the channel or ditch.

Plans and Specifications

Plans and specifications for Spoilbank Spreading shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

SPRING DEVELOPMENT

Definition

Improving springs and seeps by excavating, cleaning, capping, or providing collection and storage facilities. Does not include Trough, Tank, or Pipeline.

Purpose

Spring developments usually are made to improve the distribution or to increase the quantity of livestock water supplies, but may be made for irrigation if water in suitable quantity and quality is available.

Conditions Where Practice Applies

Developments shall be confined to springs or seepage areas that appear able to furnish a dependable supply of suitable water during the planned period or periods of use.

The need for, and feasibility of, protection from flooding, sedimentation, and contamination shall be considered in determining the suitability of a site for development.

Design Criteria

Fracture and Tubular Springs

Where water issues from fractures, the individual openings shall be cleaned and enlarged as needed to provide an increase in flow. The water from these individual openings shall be collected and conveyed to a central sump or spring box by means of a tile or perforated pipeline or by a gravel-filled ditch. The collection works shall be constructed an adequate distance vertically below the elevation of the openings to permit free discharge.

Where water issues from a single opening, such as solution channels found in soluble rock formations or tunnels in lava, the opening shall be cleaned or enlarged as needed. A collection system usually will not be required, but a spring box or sump shall be installed at an elevation sufficiently low that water will not pond over the spring opening to a depth that will materially reduce the yield.

Perched or Contact Springs

Perched or contact springs occur where an impermeable layer outcrops beneath a water-bearing permeable layer. These springs shall be

developed by intercepting and collecting the flow from the water-bearing formation. Collection trenches are used for developing these types of springs.

Artesian Springs
Artesian springs shall be developed by removing obstructions, cleaning or enlarging joints or fractures, or by lowering the outlet elevation. Sumps and spring boxes shall be located so as to hold ponding over the spring outlet to a minimum.

Collection Systems
Where a collecting trench along the outcrop of the water-bearing formation is to be used, the trench shall be excavated so that it extends into the impervious layer.

An impervious cutoff wall of well-tamped clay, masonry, concrete, or other suitable material shall be constructed along the downstream side of the trench where needed to cause the flow to enter the collection system.

The collection system shall consist of drain tile or perforated pipe not less than 4 inches in diameter, or wood box drain, enclosed in a sand-gravel filter. A crushed rock or gravel backfill, not less than 12 inches deep, may be used in lieu of these types of drains. The collection system shall outlet into a spring box.

Spring Boxes
Spring boxes shall be of durable material and shall have a tight, removable cover. The boxes shall have a minimum cross sectional area of 1 1/2 square feet.

The floor of the spring box shall be not less than 6 inches below the outlet of the collection system.

Spring boxes for perched springs shall be floored with concrete unless the underlying material is solid rock or other stable impervious material.

Outlets
The outlet pipe from a spring box shall be placed not less than 6 inches above the floor of the box to provide a sediment trap. However, the outlet must not be so high as to cause a head on the spring that would reduce flow. The outlet pipe shall be installed so as to insure a watertight connection with the spring box. Measures required to protect the development from damage by freezing, flooding, sedimentation, contamination, and livestock shall be included in the design.

Plans and Specifications

Plans and specifications for installation of Spring Development shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-574-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

STREAMBANK PROTECTION

Definition

Stabilizing and protecting banks of streams or excavated channels against scour and erosion by vegetative or structural means.

Scope

This standard covers the structural means used to stabilize and protect the banks of natural streams and excavated channels. It does not cover the vegetative measures which may be used for streambank protection, either when used alone or to supplement the mechanical measures.

Purpose

Streambank protection is established to stabilize or protect streambanks for one or more of the following purposes:

1. To prevent the loss of land or damage to utilities, roads, buildings, or other facilities adjacent to the channel.

2. To maintain the capacity of the channel.

3. To control channel meander which would adversely affect downstream facilities.

4. To reduce sediment loads causing downstream damages and pollution or to improve the stream for recreational use or as a habitat for fish and wildlife.

Conditions Where Practice Applies

This practice applies to natural or excavated channels where the streambanks are subject to erosion from the action of water, ice, or debris or to damage from livestock or vehicular traffic.

Design Criteria

Since each reach of channel is unique, measures for streambank protection must be installed according to a plan and adapted to the specific site. Designs shall be developed in accordance with the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

2. The grade must be controlled, either by natural or artificial means, before any permanent type of bank protection can be considered feasible unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

3. Streambank protection shall be started at a stabilized or controlled point and ended at a stabilized or controlled point on the stream.

4. Needed channel clearing to remove stumps, fallen trees, debris and bars which force the streamflow into the streambank shall be an initial element of the work.

5. Changes in channel alignment shall be made only after an evaluation of the effect on the land use, interdependent water disposal systems, hydraulic characteristics, and existing structures.

6. Structural measures must be effective for the design flow and be able to withstand greater floods without serious damage.

7. Vegetative protection shall be considered on the upper portions of eroding banks and especially on those areas which are subject to infrequent inundation.

<u>Streambank Protection Measures</u>
The following is a partial list of elements which may be involved in a plan for streambank protection.

<u>Obstruction removal</u> - The removal of fallen trees, stumps, debris, minor ledge outcroppings and sand and gravel bars that may cause local current turbulence and deflection.

<u>Clearing</u> - The removal of trees and brush which adversely affect the growth of desirable bank vegetation.

<u>Banksloping</u> - The reduction of the slope of streambanks to provide a suitable condition for vegetative protection or for the installation of structural bank protection.

<u>Riprap</u> - Placed or dumped heavy stone, properly underlaid with a filter blanket when necessary, to provide armor protection for streambanks.

<u>Jetties</u> - Deflectors constructed of posts, piling, fencing, rock, brush or other materials which project into the stream to protect banks at curves and reaches subjected to impingement by high velocity currents.

<u>Revetments</u> - Pervious or impervious structures built on or parallel to the stream to prevent scouring streamflow velocities adjacent to the streambank.

<u>Fencing</u> - Artificial obstructions to protect vegetation needed for streambank protection or to protect critical areas from damage from stock trails or vehicular traffic.

<u>Fish and Wildlife</u>
Special attention will be given to maintaining or improving habitat for fish and wildlife.

<u>Legal Requirements</u>
All work planned and constructed must comply with applicable state laws.

Plans and Specifications

Plans and specifications for installation of Streambank Protection shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-580-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

STREAM CHANNEL STABILIZATION

Definition

Stabilizing the channel of a stream with suitable structures.

Scope

This standard covers the structural work done to control aggradation or degradation in a stream channel. It does not include work done to prevent bank cutting or meander.

Conditions Where Practice Applies

This practice applies to stream channels undergoing damaging aggradation or degradation that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, or by the installation of upstream water control facilities, and which require the application of structural measures.

Design Criteria

It is recognized that channels may aggrade or degrade during a given storm or over short periods of time. A channel is considered stable if, over long periods of time, the channel bottom remains essentially at the same elevation.

In the design of a channel for stability, consideration shall be given to the following points:

1. The character of the materials comprising the channel bottom.
2. The quantity and character of the sediments entering the reach of channel under consideration. This shall be analyzed on a basis of both present conditions and projected changes caused by changes in land use or land treatment and upstream improvements or structural measures.
3. Streamflow peaks, velocities and volumes at various flow frequencies.
4. The effects of changes in velocity of the stream produced by the structural measures.

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Structures installed to stabilize stream channels shall be designed and installed to meet Soil Conservation Service standards for the particular structure and type of construction involved.

Plans and Specifications

Plans and specifications for installation of Stream Channel Stabilization shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-584-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

STRUCTURE FOR WATER CONTROL

Definition

A structure in an irrigation or drainage system or channel improvement for water management that conveys water, controls the direction or rate of flow, or maintains a desired water surface elevation in a natural or artificial channel. Also includes any structure for managing water levels for wildlife or other purposes. (Does not include Grade Stabilization Structures.)

Scope

This standard applies to the structures normally installed in a well planned irrigation or drainage system, channel improvement project, or wildlife facility for the conveyance, flow control, or level regulation of water. It covers the planning and functional design of such water control structures but not the detailed design criteria or construction specifications for specific structures. It does not include structural components or irrigation pipelines or subsurface drains.

Purpose

Water control structures are installed to control the stage, discharge, distribution, delivery or direction of flow of water in open channels, or water use areas.

Conditions Where Practice Applies

This practice applies wherever a permanent structure is needed as an integral part of an irrigation, drainage, or other water control system, or channel improvement project to serve one or more of the following functions:

1. To control erosion and delivery as water is conducted from one elevation to a lower elevation within, to, or from a ditch, channel, or canal. Typical structures: drops, chutes, turnouts, surface water inlets, head gates, pump boxes, stilling basins.

2. To control the elevation of water in drainage or irrigation ditches. Typical structure: checks.

3. To control the division or measurement of irrigation water. Typical structures: division boxes, water measurement devices.

4. To protect pipelines from the entry of trash, debris, or weed seeds. Typical structure: debris screens.

5. To control direction of channel flow resulting from tides or backflow from flooding. Typical structure: tide and drainage gates.

6. To control water table or removal of surface or subsurface water of adjoining land, to flood land for frost protection or to manage water levels for wildlife or recreational purposes. Typical structures: water level control structures, pipe drop inlets, box inlets.

7. To provide conveyance for water over, under, or along a ditch, canal, road, railroad or other barrier. Typical structures: bridges, culverts, flumes, inverted siphons.

Design Criteria

Structures shall be designed on an individual job basis, or applicable SCS standard drawings shall be adapted, to meet site conditions and functional requirements as part of an approved and overall engineering plan for an irrigation, drainage, wildlife or recreational development, or channel improvement project.

The plan shall specify the location, grades, dimensions, materials, and hydraulic and structural requirements for the individual structure.

Plans and Specifications

Plans and specifications for installation of Structures for Water Control shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

TERRACE, BASIN

Definition

A form of level terrace with closed ends constructed on non-cropland with permeable soils and designed to impound a given amount of runoff from the drainage area above it.

Scope

This standard covers the planning and design of basin terraces. It does not apply to Gradient, Level, or Parallel Terraces, or Diversions.

Purpose

Basin terraces are constructed to retain runoff from non-cropland areas, check erosion on the lower slopes, prevent gully development, reduce flooding, increase infiltration opportunity and reduce pollution from sediment and runoff.

Conditions Where Practice Applies

This practice is applicable on sites where:

1. Runoff from higher lying areas will damage crop or pastureland; conservation practices such as terraces, farm ponds, and similar structural installations; roads, buildings, or other cultural features.

2. The soil is deep and capable of absorbing and storing extra water.

Design Criteria

Capacity
The storage capacity of the terrace, without overtopping, shall be adequate to handle the expected runoff volume of a 10-year frequency 24-hour storm. Those designed to function in connection with other structures shall have enough capacity to store the runoff volume expected from a storm of a frequency consistent with the hazard involved.

Cross Section
The channel may be parabolic, V-shaped, or trapezoidal. The terrace shall have stable side slopes. The ridge height shall include a reasonable settlement factor. The terrace ridge shall have a minimum top width of 3 feet at the design elevation. The elevation of the top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement.

End Closures
The end closures are a part of the terrace and must be made before the terraces are considered complete. The cross section of end closures need not meet the terrace dimensions.

Plans and Specifications

Plans and specifications for installation of Basin Terraces shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-599-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

TERRACE, GRADIENT

Definition

An earth embankment or a ridge and channel constructed across the slope at a suitable spacing and with an acceptable grade.

Scope

This standard covers the planning and design of gradient terraces. It does not apply to diversions.

Purpose

Gradient terraces are constructed to reduce erosion damage and pollution by intercepting surface runoff and conducting it to a stable outlet at a nonerosive velocity.

Conditions Where Practice Applies

Gradient terraces normally are limited to cropland having a water erosion problem. They shall not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. The topography must be such that farmable terraces can be constructed. Gradient terraces may be used only where suitable outlets are or will be made available.

Design Criteria

Spacing

The maximum spacing of gradient terraces shall be determined by one of the following methods:

1. In all areas where data are available for applying the Universal Equation for predicting soil loss, the horizontal spacing shall not exceed the slope length determined for contour cultivation by using the allowable soil loss, the most intensive use expected for the land, and the expected level of management.

2. In other areas, the maximum vertical spacing shall be determined by the equation V.I. = xs + y

Where: V.I. = vertical interval in feet
x = a variable with values from 0.4 to 0.8
s = land slope in feet per 100 feet
y = a variable with values from 1.0 to 4.0

Values of x for different zones are shown in Figure 1. The zone boundaries are not to be considered inflexible. Moderate adjustments may be made for areas adjacent to the boundaries to provide uniform specifications for conditions that are similar with respect to soils, topography, type of farming, and other pertinent characteristics. Values of y are influenced by soil erodibility, cropping systems and crop management practices. The lower values are applicable to erosive soils with conventional tillage methods where little to no residue is left on the surface. The high value is applicable only to erosion resistant soils where no-plow or mulch tillage methods which leave a large amount of residue (1.5 tons of straw equivalent) on the surface are used.

Vertical spacings determined by either of the above methods may be increased as much as 0.5 foot or 10 percent, whichever is greater, to provide better alignment or location, to miss obstacles in the field, to adjust for farm machinery, or to reach a satisfactory outlet.

The drainage area above the top terrace shall not exceed the area that would be drained by a terrace of equal length with normal spacing.

Alignment
Terraces in a system shall be made as nearly parallel as practicable. Land smoothing, a moderate amount of cutting and filling along the terrace line, use of multiple outlets, variations in grades, and other methods shall be used as needed to improve alignment.

Capacity
The terrace shall have enough capacity to handle the peak runoff expected from a 10-year-frequency storm without overtopping.

Cross Section
The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. The ridge height shall include a reasonable settlement factor. The ridge shall have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel shall be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent.

The minimum constructed cross section shall meet the design dimensions.

The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace shall have cross section equal to that specified for the terrace channel.

Channel Grade

Channel grades may be either uniform or variable with a maximum grade of 0.6 foot per 100 feet of length. For short distances, terrace grades may be increased to improve alignment. The channel velocity shall not exceed that which is non-erosive for the soil type with the planned treatment.

Outlet

All gradient terraces must have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative outlets shall be installed before terrace construction, if needed to insure establishment of vegetative cover in the outlet channel.

The design elevation of the water surface of the terrace shall not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

Plans and Specifications

Plans and specifications for installation of Gradient Terraces shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

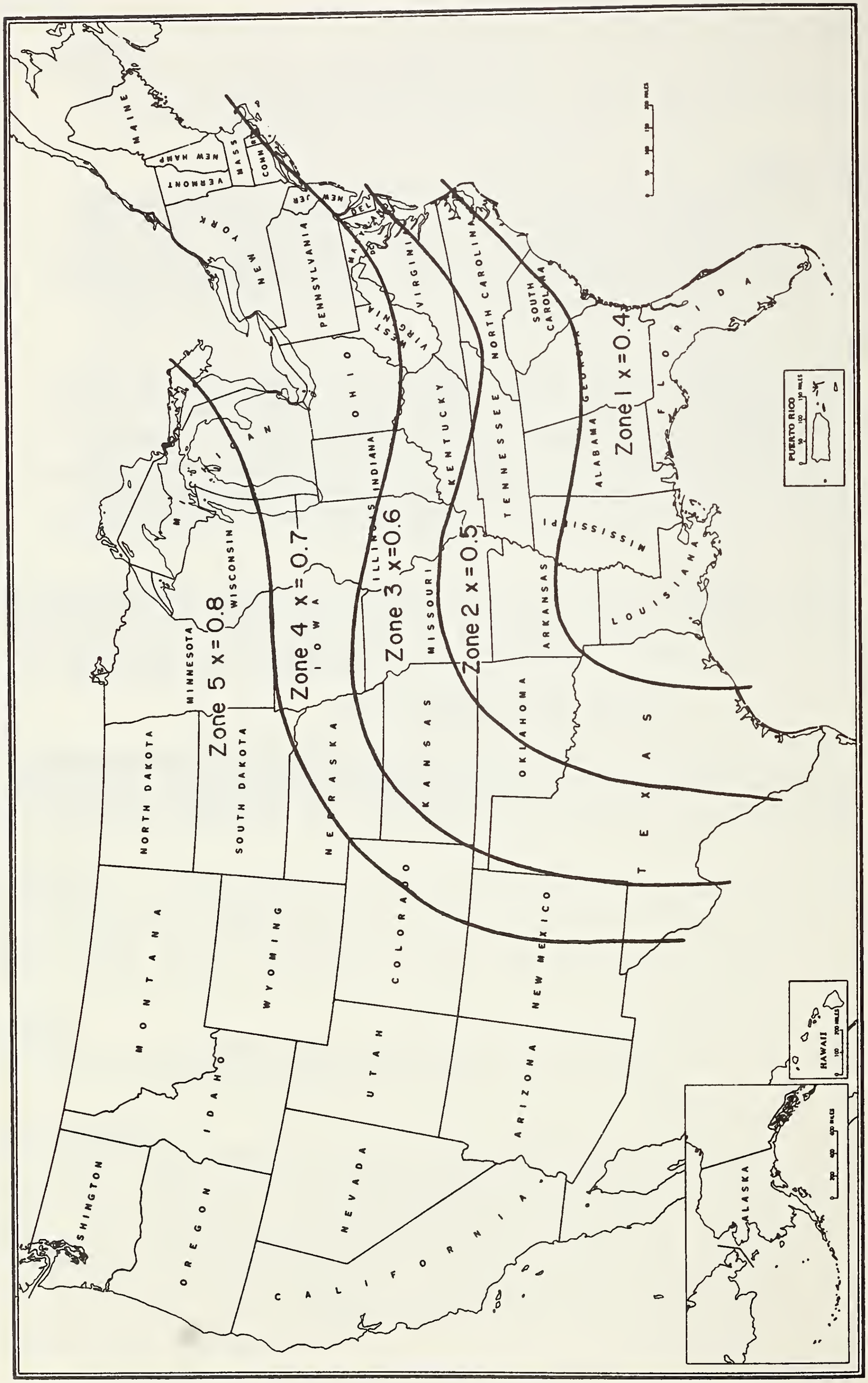

Figure I
Values of x in equation V.I=xs+y

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

TERRACE, LEVEL

Definition

An earth embankment or a ridge and channel constructed across the slope at a suitable spacing with no grade.

Scope

This standard covers the planning and design of level terraces. It does not apply to Diversions.

Purpose

Level terraces are constructed to conserve moisture, to control erosion, and reduce pollution.

Conditions Where Practice Applies

Level terraces shall be constructed only on deep soils that are capable of absorbing and storing extra water without appreciable crop damage and in areas where the rainfall pattern is such that storage of rainfall in the soil, rather than removal, is practical and desirable.

They shall not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. In cultivated areas the topography must be such that farmable terraces can be constructed.

Design Criteria

Spacing

Level terraces shall be spaced to solve adequately the existing problem, whether it be the need for better moisture distribution, erosion control, or both. The maximum spacing of level terraces shall be determined by one of the following methods:

1. In all areas where data are available for applying the Universal Equation for predicting soil loss, the horizontal spacing of terraces shall not exceed the slope length determined for contour cultivation by using the allowable soil loss, the most intensive use expected for the land, and the expected level of management.

2. In other areas, the maximum vertical spacing shall be determined by the equation V.I. = 0.8s + y

   Where: V.I. = vertical interval in feet
   s = land slope in feet per 100 feet
   y = a variable with values from 1.0 to 4.0

   Values of y are influenced by soil erodibility, cropping systems, and crop management practices. The lower values are applicable to erosive soils with conventional tillage methods where little or no residue is left on the surface. The high value is applicable only to erosion resistant soils where no-plow or mulch tillage methods, which leave a large amount of residue (1.5 tons of straw equivalent) on the surface are used.

Vertical spacings determined by either of the above methods may be increased as much as 0.5 foot or 10 percent, whichever is greater, to provide better location or alignment, to miss obstacles in the field, to adjust for farm machinery, or to reach a satisfactory outlet.

The drainage area above the top terrace shall not exceed the area that would be drained by a terrace of equal length with normal spacing.

Alignment

Adjacent terraces shall be made as nearly parallel as practicable. Land smoothing, a moderate amount of cutting or filling along the terrace, and other methods shall be used as needed to improve alignment.

Capacity

The capacity of the terrace without overtopping shall be adequate to handle the runoff expected from a 10-year-frequency storm. The runoff volume of a 10-year-frequency, 24-hour storm shall be considered in determining required storage capacity for closed-end terraces.

Cross Section

The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the machinery used. The ridge height as constructed shall include a reasonable settlement factor. The ridge shall have a minimum top width of 3.0 feet at the design height.

The minimum cross section shall meet the design dimensions. The elevation of the top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement.

Terrace End Closures

Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures will be used only on soils and slopes where the stored water will be absorbed by the soil without crop damage.

Where closed-end or partially closed-end terraces are specified, the end closures are a part of the terrace and must be made before the terraces are considered complete.

Terrace Lengths

For level terraces of given dimensions, the volume of water stored above the terrace is proportional to the length. Therefore, it is important that the length be held within reason so that damage in case of a break will be minimized. Terrace length shall not exceed 3,500 feet unless the channel is blocked at intervals to provide segments of this length.

Outlets

An adequate outlet shall be provided where terraces have open ends or partial end closures. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative outlets shall be installed before terrace construction, if needed, to insure establishment of vegetative cover in the outlet channel.

The design elevation of the water surface in the terrace shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Partial end closures shall not be more than half the effective height of the terrace ridge. Full end closures are those exceeding half of the effective height of the ridge. The cross section of end closures need not meet the terrace dimensions.

The opening of the outlet end of open-end level terraces shall have a cross section at least equal to that specified for the channel of the terrace.

Plans and Specifications

Plans and specifications for installation of Level Terraces shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

TERRACE, PARALLEL

Definition

An earth embankment or a ridge and channel in parallel constructed across the slope at a suitable spacing and with an acceptable grade.

Purpose

Parallel terraces are constructed to reduce erosion and pollution, conserve moisture, and provide a more farmable terrace system.

Conditions Where Practice Applies

Parallel gradient terraces normally are limited to cropland having a water erosion problem. Gradient terraces may be used only where suitable outlets are or will be made available.

Level terraces are limited to deep soils that are capable of absorbing and storing extra water without appreciable crop damage and in areas where the rainfall pattern is such that storage of rainfall in the soil, rather than removal is practical and desirable.

Terraces shall not be constructed on deep sands or on soils that are too stony, steep or shallow to permit practical and economical installation and maintenance. The topography must be such that farmable terraces can be constructed.

Design Criteria

Criteria for spacing, alignment, capacity, cross-section, grades, outlets, end closures, and lengths shall meet the requirements as outlined in SCS Engineering Standards for Terraces, Gradient, Code 600, and Terrace, Level, Code 602, as applicable.

Plans and Specifications

Plans and specifications for installation of Parallel Terraces shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

TROUGH OR TANK

Definition

A trough or tank with needed devices for water control and waste water disposal installed to provide drinking water for livestock.

Scope

This standard covers all trough or tank installations to provide livestock watering facilities supplied from a spring, reservoir, well or other source.

Purpose

To provide watering facilities at selected locations which will bring about the desired protection of vegetative cover through proper distribution of grazing or better grassland management.

Conditions Where Practice Applies

This practice applies where there is a need for new or improved watering places to permit the desired level of grassland management and reduce health hazards to livestock.

Design Criteria

The trough or tank shall have adequate capacity to meet the water requirements of the livestock it is to serve. This will include the storage volume necessary to carry over between periods of replenishment. The site shall be well drained and areas adjacent to the trough or tank that will be trampled by livestock shall be graveled, paved, or otherwise treated to provide firm footing. Automatic water level control and overflow facilities shall be provided. Overflow shall be piped to a desirable point of release. The quality and durability of all materials shall be in keeping with the planned useful life of the installation.

Plans and Specifications

Plans and specifications for installation of Troughs and Tanks shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-614-1 for items to be considered in development of specifications.

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SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

VERTICAL DRAIN

Definition

A well, pipe, pit, or bore into porous, underground strata into which drainage water can be discharged.

Scope

This standard applies to the practice of installing a well, pipe, pit, or bore into porous underground strata into which drainage water can be discharged.

Purpose

The purpose of this practice is to provide an outlet for drainage water from a surface or subsurface drainage system.

Conditions Where Practice Applies

This practice is applicable in locations where the underlying strata can receive and transmit, or store the design drainage flow, and other drainage outlets are not available and cannot be provided at a reasonable cost. The practice is applicable only in locations where a determination has been made that it is not contrary to state laws or regulations, and that it will not cause pollution of underground waters.

Design Criteria

The number and size of vertical drains shall be adequate to discharge the design drainage flow into the underlying stratum or strata. The number, size, and location of the drains shall be based on a field determination of the depth, permeability, porosity, thickness and extent of the strata.

The minimum diameter of shallow uncased wells shall be 24 inches and of deep cased wells it shall be 4 inches.

A suitable filter system, desilting basin, or other means for the removal of sediment from the water before it enters the well shall be provided.

Well casings shall be of adequate strength and longevity to serve planned needs.

Plans and Specifications

Plans and specifications for installation of Vertical Drains shall be in keeping with this standard, and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

WATERSPREADING

Definition

Diverting runoff from natural channels or gullies by means of a system of dams, dikes, or ditches and spreading it over relatively flat areas.

Purpose

To provide moisture for plants on land areas that can make effective use of additional moisture to supplement natural precipitation.

Conditions Where Practice Applies

All applicable state laws or water rights must be complied with in design, layout, and construction of the system.

Waterspreading systems apply to those locations where climatic conditions are such that the additional moisture can be expected to improve plant growth. Areas having average annual precipitation of from 8 to 25 inches benefit most from waterspreading.

Waterspreading systems differ from irrigation systems in that the timing of water application is dependent upon periods when runoff occurs and the depth of application depends on the nature of the flood hydrograph, the intake characteristics of the soil, and the type of spreading system used.

The expected benefits must justify the costs of installation, operation and maintenance.

Soils shall be relatively free of problems of alkalinity and salinity. They shall have a moderate to high water-holding capacity. The soil profile shall be deep enough that the water-holding capacity will be at least 4 inches for the normal extraction depth of the plants to be grown. Intake rates shall be slow enough to permit the spread of flood waters by surface methods.

The topography of the spreading area shall be relatively flat, smooth, and free of rills or channels that would tend to concentrate the spread of water.

The normal seasonal distribution and volumes of runoff water from both rainfall and snowmelt shall be such that the water applied by the spreading system will effectively increase plant growth. The diverted

storm flows shall not be great enough to cause undue maintenance problems or contain salts or sediment in kinds and amounts that would be damaging to the spreading area.

The plants to be grown shall be those which will withstand inundation for the length of time and at the season contemplated in the design.

The combination of soils, slopes and plants shall be such that the area will withstand the application of flood waters without scour or erosion losses beyond allowable limits.

Care shall be exercised to create no detrimental effects for fish and wildlife.

Design Criteria

Depth of Application

If the floodwater is to be spread over the area as diffused flow, the depth of application will be the depth of water that the soil will absorb in a period equal to the estimated flow duration. On the more permeable soils, this may be more than needed to fill the root zone.

Where the water is to be impounded on the spreading area, the depth of application shall equal the water-holding capacity of the soil profile for the effective root-zone of the plants to be grown.

Drainage Area

The contributing area for a dependable water supply shall be such that the volume of divertable flow needed for the design water application can be expected on an average of 8 years in 10. Divertable flow is the volume available and feasible for diversion in excess of any base flow that must be bypassed to satisfy existing rights.

Systems with less than a dependable water supply must necessarily be simple in nature if the expected benefits are to justify the installation costs. Generally they are planned where the needed application volume can be expected on an average of at least 1 year in 2.

Excess Water Disposal

Provisions shall be made so that excess water from the system can be returned to the stream channel without causing excessive erosion or damage to other interests.

Diversion Works

The diversion works shall be automatic in nature and require no manual control to divert the stream onto the spreading area, except on water courses that have expected flow durations of more than 24 hours. The works shall be capable of safely bypassing the peak flood flow. Suitable controls shall be provided so as to permit only the desired

rate of flow to enter the conveyance system. The control device shall be adjustable to exclude flow from the spreading area when crops are to be harvested by mechanical means.

Conveyance System
The conveyance system shall have the capacity to safely convey the design flow from the diversion works to the spreading area.

Ditches, Dikes, Diversions, and Related Structures
Ditches, dikes, diversions, and related structures shall be arranged and located to spread the diffused flow over the land surface or to pond the water over the land in accordance with the type of system selected. Freeboard for dikes or diversions shall be not less than 0.5 feet. Side slopes of dikes, diversions, and ditches shall be such that they are stable and will not interfere unduly with management or harvesting operations. All dikes, diversions, ditches, and related structures shall meet Soil Conservation Service standards for the particular structure or type of construction involved.

Plans and Specifications

Plans and specifications for installation of Waterspreading shall be in keeping with this standard and shall describe the requirements for application of the practice to achieve its intended purpose. See page S-640-1 for items to be considered in development of specifications.

SOIL CONSERVATION SERVICE

ENGINEERING STANDARD

WELL

Definition

A well constructed or improved to provide water for irrigation, livestock, wildlife, or recreation.

Scope

This standard applies to drilled, driven and dug wells developed to supply water from an underground source. It does not include pumps installed in the well, or above ground installations such as pumping plants, pipelines or tanks.

Test wells established for investigational purposes prior to the installation of a permanent well are considered temporary and are not covered by this standard.

Purposes

To facilitate proper use of vegetation on range, pastures and wildlife areas; to supply the water requirements of livestock and wildlife; to provide an adequate supply of water for conservation irrigation; and to provide for human use at recreation sites.

Conditions Where Practice Applies

All irrigation wells shall be planned and located to serve as a source of water for an irrigation water distribution or conveyance system designed to facilitate the conservation use of the soil and water resources on a farm or group of farms.

Irrigation wells are limited to geological site conditions where sufficiently large volumes of underground water are available at a rate which will permit practical irrigation of the land on which the water is to be used. Wells may be the only source of supply or they may supplement other sources. The land on which the water is to be used must be suitable for the production of locally adapted crops under irrigation farming. The water quality must be such that it will not materially reduce the productive capacity of the soil on which it is to be used.

Wells are applicable on ranges, pastures, wildlife, and recreation areas where present facilities are inadequate, and the underground water supply is adequate in quantity and quality for the purpose to be served and can be developed at an economical cost.

Wells for livestock water must be adequately dispersed in location to facilitate distribution of grazing.

All wells shall comply with state water laws and regulations. Wells at recreation sites shall comply with applicable regulations of the State Department of Health, or other State agency having jurisdiction.

Design Criteria

General

The criteria for design given in "Tentative American Society of Agricultural Engineers Recommendations, ASAE R 283(T), Designing and Constructing Water Wells for Irrigation," provides good guidance for well design and construction.

Feasibility

The feasibility of development and type of well installed shall be based on reliable local experience or on detailed investigations including test well drilling and geologic and hydraulic analysis.

Casing and Materials

Wells shall be cased, except that the lower sections of a well passing through consolidated strata do not require casing. Materials shall be in accordance with the requirements of Engineering Specifications for Materials.

Screens

All wells finished in unconsolidated aquifers shall be equipped with manufactured screen sections, well points, or field perforated sections meeting the criteria stated below.

The screen openings for aquifer material of near uniform size shall be slightly smaller than the average diameter of the aquifer material. For graded aquifer materials (of non-uniform gradation) the screen openings shall be such that 25 to 40 percent of the aquifer material is larger than the screen opening. In wells using a gravel pack envelope the screen shall have openings of a size that will exclude at least 85 percent of the gravel pack material. The length and open area of the screen shall be sufficient to maintain the entrance velocity of water into the well at an acceptable level, preferably less than one-tenth foot per second.

The position of the screen in the well will be governed by the depth of the aquifer below the ground surface and the thickness of aquifer to be penetrated by the well. Where practical, the top elevation of the screen should be below the lowest water level expected during

pumping and be located opposite the most permeable areas in the water bearing strata.

Gravel Pack

Filter packs will be used in wells developed in stratas composed of fine material of relatively uniform grain size to prevent aquifer materials from passing through the well screen or perforated casing. The pack shall be 3 to 12 inches thick and shall be composed of sand or gravel material having a grain size 5 to 12 times the grain size of the strata material.

Sanitary Protection

Groundwater sources should be located a safe distance from sources of contamination. In cases where sources are severely limited, a ground-water aquifer that might become contaminated may be considered for a water supply for human consumption if adequate treatment is provided.

Minimum recommended distances between water supplies and sources of contamination are:

Contamination Source	Distance to Well or Suction Line
Sewer	50 feet
Septic tank	100 feet
Disposal field	100 feet
Seepage pit	150 feet
Dry well	50 feet
Cesspool	150 feet
Waste disposal lagoons	300 feet

If at all possible, the well should be located on ground that is higher than any source of contamination. Drainage that might reach the source from areas used by livestock should be diverted.

Each well shall be provided with a watertight cover or seal to prevent contaminated water or other objectionable material from entering the well. The annular space around the casing shall be filled with cement grout, bentonite clay, or other suitable material to a depth which will seal off surface waters. A positive seal shall be provided between the casing and the impervious material overlying the aquifer of artesian wells.

Installation Requirements

Alignment
Drilled wells shall be round, plumb and aligned so as to permit satisfactory installation and operation of a pump of the proposed size and type, to the greatest anticipated depth of setting.

Casing Installation
In consolidated formations, the casing shall extend from the ground surface through the overburden material to an elevation at least 2 feet into the consolidated foundation.

In unconsolidated formations the casing shall extend from the ground to the screen.

For artesian aquifers, the casing shall be sealed into the overlying impermeable formations so as to retain the artesian pressure.

When a water bearing formation containing water of poor quality is penetrated, the formation shall be sealed off to prevent the infiltration of poor quality water into the well and the developed aquifer.

Plastic well casing shall be equipped with a steel driving shoe and shall be placed with very little driving.

Developing
The well shall be developed until it has stopped producing detrimental quantities of sand when the continuous discharge rate is approximately 20 percent greater than the anticipated normal production rate.

Protection
All wells shall be completed at the ground surface so as to exclude the entrance of surface and near surface water.

Wells used for human consumption shall have the annular space outside the casing filled with a watertight cement grout or clays with similar sealing properties from the surface to a minimum of 10 feet below the ground surface. The casing shall be surrounded at the ground surface by a 4-inch concrete slab extending at least 2 feet in all directions. A sanitary well seal shall be installed at the top of the well casing to prevent the entrance of contaminated water or other objectionable material.

Gravel Pack
When gravel packing is used, it shall be of the specified gradation and thickness and shall be carefully placed to prevent segregation and bridging. Gravel pack materials shall extend a minimum of 10 feet above the top of the perforated or screened section and extend through the length of the water-bearing formation.

Plans and Specifications

Plans and specifications for Wells shall be in keeping with this Standard and shall describe the requirements for application of the practice to achieve its intended purposes.

ENGINEERING SPECIFICATIONS FOR MATERIALS

Materials

Casing materials may be pipe made of steel, wrought iron, plastic, copper, asbestos-cement, concrete or other similar material of equivalent strength and durability.

New metal pipe or new plastic pipe shall be used for well casing in drilled wells. New metal pipe only shall be used for driven wells. Plastic casing shall be NSF-approved for transport of potable water supplies where the water will be used for human consumption.

Polyvinyl chloride plastic well casing shall be Schedule 40 or Schedule 80 pipe and shall be limited to a maximum installation depth of 200 feet. Specifications for wall thickness and for diameter of polyvinyl chloride plastic pipe (PVC), ASTM D 1785, NSF-approved, are given in Table 1.

Plastic well casings made of virgin, white, high-impact, rubber-modified polystyrene material, such as Dow Chemical Company Styron 456 or Cosden 825-D or equal, shall be limited to an installation depth of 300 feet. Specifications for thickness by diameter of such polystyrene plastic casing are given in Table 2.

Size of Plastic Casing

Plastic well casings shall be no larger than 6-inches diameter, nominal.

Joints in Plastic Casing

Joints shall be other than screw type.

Table 1

POLYVINYL CHLORIDE (PVC) PIPE FOR WELL CASING

Nominal Size	Outside Diameter	Inside Diameter	Minimum Wall Thickness	Outside Diameter	Inside Diameter	Minimum Wall Thickness
	PVC 1220 SCHEDULE 40			PVC 1220 SCHEDULE 80		
inches	inches	inches	inches	inches	inches	inches
1 1/2	1.900	1.610	0.145	1.900	1.500	.200
2	2.375	2.067	0.154	2.375	1.939	.218
2 1/2	2.875	2.469	0.203	2.875	2.323	.276
3	3.500	3.068	0.216	3.500	2.900	.300
4	4.500	4.026	0.237	4.500	3.826	.337
6	6.625	6.065	0.280	6.625	5.761	.432

Table 2

HIGH-IMPACT, RUBBER-MODIFIED POLYSTYRENE PIPE FOR WELL CASING

Nominal Diameter	Minimum Wall Thickness
Inches	Inches
4	0.220
5	0.250
6	0.300

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

ACCESS ROAD

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limitations. The completed job shall present a workmanlike finish. Consideration will be given to the following:

1. Removal and disposal of trees, stumps, roots, brush, weeds and other objectional material from the work area.

2. Removal of unsuitable material from the roadbed area.

3. Grading, subgrade preparation, and compaction requirements.

4. Surfacing requirements, if needed.

5. Planned and laid out recognizing good aesthetic principles.

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CLEARING AND SNAGGING

All trees, stumps, and brush within the perimeter of the channel shall be cut as close to ground level as the cutting tools will permit. Where other areas are to be cleared, the trees, brush and other woody vegetation shall be cut within the maximum distance above ground level required by the planned use of the areas and/or as specified in the project plan.

Trees shall be felled in such a manner as to avoid damage to other trees, property, and objects located outside the limits of clearing.

Down trees, logs, drifts, boulders, debris and other obstructions lying wholly or partially within the channel shall be removed. Piling, piers, headwalls, and sediment bars that obstruct the free flow of water will be removed when so designated in the project plan.

On projects where herbicide treatment is planned, the stumps and brush within the specified area shall be treated at the time of clearing in accordance with the recommendations of the manufacturers of the particular herbicide specified or being used.

The use of explosives in any and all clearing and snagging operations shall be in strict compliance with applicable State statutes and regulations.

Through cultivated or high value land, trees, logs, and all combustible material resulting from the clearing and snagging operations shall be burned, buried, or piled in designated disposal areas as specified for the project. In other areas, such as woodland or range land, where burning is prohibited, material shall be disposed of in such a manner that it will not float away or re-enter the channel.

All burning shall be performed outside the channel and shall conform to regulations in effect in the area.

Residue from burning and non-combustible material shall be buried outside the channel or placed in designated disposal areas. All buried material shall have adequate earth cover to permit proper land use.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Special attention shall be given to protecting and maintaining key shade, food, and den trees and to stabilization of disturbed areas.

SOIL CONSERVATION SERVICE

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DAM, DIVERSION

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

DAM, MULTIPLE-PURPOSE

The foundation area shall be cleared of trees, stumps, roots, brush, boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. Topsoil containing excessive amounts of organic matter shall be removed. The surface of the foundation area will be thoroughly scarified before placement of the embankment material.

The cutoff trench shall be excavated to the lines and grades shown on the plans and shall be backfilled with suitable material in the same manner as specified for earth embankment. The trench should be kept free of standing water during backfill operations.

Existing stream channels crossing the foundation area shall be sloped no steeper than 1:1 and deepened and widened as necessary to remove all stones, gravel, sand, stumps, roots, and other objectionable material and to accommodate compaction equipment. Such channels shall then be backfilled with suitable material as specified for earth embankment.

The pipe conduit barrel shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed around the conduit in layers and each layer shall be thoroughly compacted.

The completed spillway excavation shall conform to the lines, grades, bottom width, and side slopes shown on the plans as nearly as skillful operation of the excavating equipment will permit.

All borrow areas outside the pool area shall be graded and left to such a manner that they are well drained.

The material placed in the fill shall be free of sod, roots, frozen soil, stones over 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately horizontal layers of such thickness that the required compaction can be obtained with the equipment used. The measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish.

Fencing and vegetation to control erosion and pollution shall be established as needed.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATION GUIDE

DEBRIS BASIN

Construction operations shall be carried out in such a manner that erosion, air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish and be pleasing to the eye.

SOIL CONSERVATION SERVICE

SPECIFICATIONS GUIDE

DIKE

All Dikes

Preparation of sites for dike construction shall be done in a manner which destroys as little vegetation outside the areas to be occupied by dikes and borrow pits as feasible. Special efforts shall be made to save trees of significant value which are not in the area to be occupied by the dike.

Construction operations shall be carried out in a manner to minimize air and water pollution and hold such pollution within legal limits. Bare areas shall be revegetated as soon as practical after earthwork is completed. A minimum area should be stripped of vegetation at any one time to provide an adequate work site.

Disposal of debris from site preparation shall be done in a manner to cause minimum pollution to the environment.

Class I Dikes

Foundation Preparation

The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod and debris. All channel banks and sharp breaks shall be sloped no steeper than 1:1. Topsoil which is high in organic matter shall be removed. The surface of the foundation shall be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, shall be excavated to lines and grades as shown on the plans. It shall be backfilled with suitable material in a manner as specified for earth embankments. The necessary compaction shall be obtained by using equipment adapted to site conditions. The trench shall be kept free of standing water during backfill operations. Material from the cutoff trench may be placed within the dike section if suitable.

Conduit Installation

All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed in layers around the conduits and their component parts and each successive layer shall be thoroughly compacted.

Embankment Construction
The material placed in the fill shall be free of all sod, roots, frozen soil, stones over 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately horizontal layers of such thickness that the required compaction can be obtained with the equipment used. The construction equipment shall be operated over the area of each layer in a way that will result in the required compaction. Special equipment shall be used when the required compaction cannot be obtained without it.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

Class II Dikes

Foundation Preparation
The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod and debris. All channel banks and sharp breaks shall be sloped no steeper than 1:1. Topsoil which is high in organic matter shall be removed. The surface of the foundation area shall be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, shall be excavated to lines and grades as shown on the plans. It shall be backfilled with suitable material in a manner as specified for earth embankment. The necessary degree of compaction shall be obtained by using equipment adapted to site conditions. The trench shall be kept free of standing water during backfill operations. The material from the cutoff trench may be placed within the dike section if suitable.

Conduit Installation
All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed in layers around the conduits and their component parts and each successive layer shall be thoroughly compacted.

Embankment Construction
The embankment material may be obtained from a selected borrow area or from a channel. In the construction of borrow trenches on the water side of the dike, an unexcavated plug at least 25 feet wide shall be left at intervals not to exceed 1320 feet.

The fill material shall be free of organic matter and other objectionable material. Placing and spreading of fill shall begin on the lowest part of the working area and continue in horizontal layers of approximate uniform thickness, preferably 6 inches thick but not more than 18 inches thick, depending on the equipment used. Where the borrow yields materials of varying texture and gradation, the more impervious material shall be placed toward the water side of the dike. The construction equipment shall be operated over the area of each layer in a manner to break up large clods and obtain compaction.

Fill material shall be moist but not too wet for equipment operations and shaping. Water shall be added to the fill material where it is too dry to permit compaction.

Dumped fill, where used, shall be placed in layers or deposited in a manner suitable to the equipment used and the material excavated. Shaping shall be done so as to break up lumps and clods of earth. Excessively wet material shall be placed to permit free drainage and shaped after it has drained. When the fill slumps due to wetness, the dike shall be constructed in stages.

Class III Dikes

The site shall be cleared of trees, brush, other vegetation, and debris. Trees and stumps shall be cut at approximate ground level. The surface shall be scarified where needed to obtain a satisfactory bond with the dike.

The spoil shall be placed to the height required for the dike and where needed to obtain stability or adequate compaction it shall be raised in stages.

Earth fill around conduits through the dike shall be thoroughly tamped.

SOIL CONSERVATION SERVICE

SPECIFICATIONS GUIDE

DRAIN

Inspection and Handling of Materials

Material for drains shall be given a rigid inspection before installation. Where applicable, clay and concrete tile shall be checked for damage from freezing and thawing prior to installation. Bituminized fiber and plastic pipe and tubing shall be protected from hazards causing deformation or warping. All material shall be satisfactory for its intended use and shall meet applicable specifications and requirements.

Placement

All drains shall be laid to line and grade and covered with approved blinding, envelope, or filter material to a depth of not less than 3 inches over the top of the drain. No reversals in grade of the conduit shall be permitted.

Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded; and when completed, the conduit shall be not less than 2 inches from rock.

Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur and so that the filter and bedding material, after backfilling, will meet the requirements of the plans and specifications.

When a filter is required, all openings in the drain shall be covered by the filter, or approximately the lower half of the drain is to be covered by the filter and the rest of the drain covered by a sheet of impervious plastic. No portion of the drain containing openings is to be left exposed under conditions which require the use of a filter.

When sand-gravel filter material is used, the trench shall be over excavated 3 inches and backfilled to grade with filter material. After placement of the drain upon the filter material, additional filter material shall be placed over the drain to fill the trench to a depth of 3 inches over the drain. A plastic sheet and friable soil can be used in lieu of filter material as the backfill over the drain when specified. The sand-gravel filter material shall be a mixture of sand and gravel within the gradation required by the base material in the trench.

General
The installing contractor shall certify that his installation complies with the requirements of these specifications, and shall name the source of materials used.

SOIL CONSERVATION SERVICE

SPECIFICATIONS GUIDE

DRAINAGE LAND GRADING

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The land surface must be free of all trash or vegetative material that would materially reduce the effectiveness of the grading operation.

The land shall be graded to the designed elevations. Fills of more than 6 inches shall be built up by spreading the soil in layers. Grading operations shall not be performed under soil moisture conditions that will result in excessive damage to soil structure.

The spoil available from adjacent ditches and the fill required for roads, dikes, etc., shall be considered in developing the grading plan.

After cuts and fills have been completed, the surface shall be smoothed to remove minor irregularities.

All grading work shall be finished in accordance with the design and to tolerances specified.

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SOIL CONSERVATION SERVICE

SPECIFICATIONS GUIDE

FLOODWATER DIVERSION

Site Preparation

The entire width of the site for the floodwater diversion, including channel, berm, and embankment shall be cleared of all trees, stumps, roots, brush, boulders, and debris. All channel banks and sharp breaks shall be sloped no steeper than 1:1 unless such sloping would likely result in a changing a stable slope into an unstable slope. Topsoil which is high in organic matter shall be removed. The ground surface where the embankment is to be placed shall be thoroughly scarified before placement of the embankment material.

Excavation and Construction of Embankment

Excavation of the channel and placement of spoil in the embankment shall progress simultaneously from the outlet upstream. The channel shall be excavated to the lines and grades shown in the plans and as staked in the field, and the embankment shall be built to the dimensions specified in the plans and as staked in the field. Where the excavation and fill required do not balance, the responsible technician shall specify the areas where borrow is to be obtained for fill or the place and manner of disposition of excess excavated material.

Construction operations will be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

Vegetation shall be established as specified in the plans.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

FLOODWATER RETARDING STRUCTURE

Construction of structures within the scope of Engineering Memorandum 27 shall be in accord with the Guide Specification contained in National Engineering Handbook, Section 20.

Structures below the scope of Engineering Memorandum 27 shall have, as a minimum, specifications which consider the items included in the Specification Guide for Pond (378).

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized. Laws concerning pollution abatement shall be complied with.

The completed job shall present a workmanlike finish.

Fencing and vegetative measures needed to control erosion and for management should be incorporated as needed.

SOIL CONSERVATION SERVICE

SPECIFICATIONS GUIDE

FLOODWAY

Construction will be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The areas to be excavated or occupied by dikes or spoil banks shall be cleared of trees, brush, other vegetation, and debris. Other areas within the floodway to be cleared as part of the required improvement shall be specified. Clearing shall be done in a manner which destroys as little vegetation outside the limits of the floodway as feasible. Special efforts shall be made to save large trees in the floodway which have significant value for wildlife food or shelter or for aesthetics of the site. Cleared debris shall be removed from the floodway and disposed of as specified.

Excavation shall be made as provided in the plans and specifications and as staked in the field. Spoil from excavation shall be disposed of as specified.

Dike construction shall be in accordance with the standards for the particular class of dike and as provided in the plans and specifications and as staked in the field.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

GRADE STABILIZATION STRUCTURE

Specified materials shall be of a quality capable of providing the stability and durability required to achieve the planned objective with appropriate factors of safety.

Specifications for installation of structures, within the scope of Engineering Memorandum-27, will be in accord with the Guide Specifications contained in National Engineering Handbook, Section 20.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

Fencing and stabilization of disturbed areas shall be specified as required.

The complete job shall present a workmanlike finish.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION CANAL OR LATERAL

Specifications shall include consideration of the following items in addition to those required in the standard:

The foundation area for all canal and lateral embankments shall be cleared of all trees, brush, weeds, sod, loose rock, or other material not suitable for the subgrade.

Embankment materials shall be free of brush, roots, sod, large rocks, or other material not suitable for making compacted fills.

Excavation shall be to the neat lines and grades shown on the plans and established at the field location. Excavated materials shall be used in designated fill locations for compacted earth embankment or wasted to prescribed waste locations. Excavation in borrow areas shall be at locations prescribed and to lines and grades established in the field.

Earthfill embankments shall be constructed to the neat lines and grades shown on the plans and established at the field location. Moisture content and methods of placing and compacting the material shall be such that a firm, stable embankment will result. Below the design water surface elevation, fill material shall be placed in horizontal lifts of such thickness that proper compaction and any prescribed densities will be obtained.

Over-excavation within the channel area or over-fill on the canal or lateral banks will be permitted if it does not interfere with the function of the canal or related structures and if the finished section is generally smooth.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION DITCH AND CANAL LINING
Non-reinforced Concrete

Specifications shall include consideration of the following items in addition to those required in the standard:

The foundation area for all ditch embankments and/or ditch pads shall be cleared of all trees, weeds, sod, loose rock, or other materials not suitable for the subgrade. All large trees with root systems that are a hazard to the ditch or canal lining shall be removed.

Embankment materials shall be free of brush, roots, sod, large rocks, or other material not suitable for making compacted fills.

Moisture content and methods of placing and compacting the material shall be such that a firm, stable embankment will result. The fill material shall be placed in horizontal lifts of such thickness that proper compaction and prescribed densities will be obtained.

Ditches and canals shall be excavated to the neat lines of the specified cross section and finished with a smooth, firm surface. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alignment shall be permitted.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION DITCH AND CANAL LINING
Flexible Membrane

Specifications shall include consideration of the following item in addition to those required in the standard:

Sub-grades on which flexible membranes will be placed shall be raked to remove all large clods, roots, brush, sod, or rocks which might endanger the membrane. Rolling the sub-grade is recommended to provide an extra measure of safety against punctures. In rocky areas, a cushion layer of fine soil shall be provided to protect against irregularities that cannot be removed by rolling.

Construction operations shall be done in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION DITCH AND CANAL LINING
Galvanized Steel

Specifications shall include consideration of the following items in addition to those in the standard:

The foundation area for all ditch embankments and/or ditch pads shall be cleared of all trees, weeds, sod, loose rock, boggy soil, or other material not suitable for the subgrade. All nearby trees with root systems that are a hazard to the lining shall be removed.

Ditches and canals shall be excavated to the neat lines of the specified cross section and finished with a smooth, firm surface. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

Embankment materials shall be free of brush, roots, sod, rocks, hard clods larger than 6 inches, frozen soil or other material not suitable for making compacted fills.

Moisture content and methods of placing and compacting the embankment and backfill materials shall be such that a firm, stable embankment will result.

The completed work shall conform to the lines, grades, dimensions, and side slopes shown on the plans or layout as nearly as skillful operation of proper construction equipment will permit.

The lining shall be placed so there are no abrupt deviations from the designed alignment.

Joints shall be flexibly joined to absorb changes in length due to temperature and constructed so that they will remain watertight.

The anchorage section of the lining shall be adequately covered with earth.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

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SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION FIELD DITCH

Definition

Specifications shall include consideration of the following items in addition to those in the standard:

The foundation area for all ditch embankments and ditch pads shall be cleared of all trees, weeds, sods, loose rock or other material not suitable for the subgrade.

The field ditch shall be constructed to the designed line, grade, and cross section.

Embankment materials shall be free of brush, roots, sod, large rocks, or other material not suitable for making compacted fills.

Over-excavation within the channel area or overfill on the ditch banks is permissible if it does not interfere with the function of the ditch or the related structures.

Moisture content and methods of placing and compacting fill material shall be such that a firm, stable embankment will result. The fill material shall be placed in horizontal lifts of such thickness that proper compaction and prescribed densities will be obtained.

The finished section shall be generally smooth and of good appearance.

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ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION LAND LEVELING

Specifications shall include consideration of the following item in addition to those required in the standard:

All lands to be leveled shall be cleared of brush, crop residue, trash, and vegetative material.

The land shall be leveled to the designed grade or grades. Fills of more than 6 inches shall be built up by spreading the soil in successive layers. Leveling operations shall not be performed under soil moisture conditions that will result in excessive damage to soil structure.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

IRRIGATION WATER MANAGEMENT

The amount of water needed for each irrigation shall be determined and applied with an adapted irrigation method.

The timing or scheduling of irrigation shall be in conformity with the moisture requirements for optimum production.

Water shall be applied at a rate and in such a manner that it will not cause excessive soil erosion.

The irrigation shall be performed in a manner that will attain average field irrigation efficiencies listed in the local irrigation guide for the soil, slope, crop and method of irrigation.

In lieu of an actual evaluation at each irrigation, evidence that the physical layout of the irrigated area meets the requirements of the local irrigation guide plus the technician's evaluation as to the knowledge and use of the principles of water management by the irrigator is acceptable in determining that good water management is being practiced.

SOIL CONSERVATION SERVICE

SPECIFICATIONS GUIDE

LAND SMOOTHING

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The land to be smoothed shall be cleared of vegetative matter and trash.

Irregularities which apparently would not be removed by three passes of a land plane or land leveler should be rough graded to more uniform topography prior to the overall smoothing operation.

The ground surface should be plowed or disked prior to smoothing.

At least three passes of a land plane or leveler should be made over the land to be smoothed in different directions, consisting of one pass along each diagonal and the last pass generally in the direction of cultivation or irrigation.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

PIPELINE

Placement

Pipelines shall be placed so they are protected against hazards imposed by traffic, farm operations, freezing temperatures or soil cracking. Other means of protection must be provided where the depth required for protection is impracticable due to shallow soils over rock or for other reasons.

Trenches for plastic pipelines shall be free of rocks and other sharp edged materials and the pipe shall be placed in a "snake-like" position.

Testing

Before backfilling, the pipe shall be filled with water and tested at design working head or a minimum head of 10 feet whichever is greater. All leaks shall be repaired and the test repeated before backfilling starts.

Backfilling

All backfilling shall be completed before the line is placed in service. For plastic or copper pipe the initial backfill shall be of selected material, free from rocks or other sharp edged material that would damage the pipe. This initial fill shall be compacted around the pipe to a density at least equal to the natural density of the trench sidewalls. Deformation or displacement of the pipe must not occur during backfilling.

Backfill of plastic pipe should be done after the pipe reaches the same temperature as the water or soil. This can be done in a number of ways such as filling with water or by leaving the trench open overnight before backfilling.

Installation and backfilling should be done in a workmanlike manner, provisions for stabilization of disturbed areas and control of erosion should be installed as necessary.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

FARM POND

Embankment Ponds

The foundation area shall be cleared of trees, stumps, roots, brush, boulders, sod, and debris. Channel banks and sharp breaks shall be sloped to no steeper than 1:1. Topsoil containing excessive amounts of organic matter shall be removed. The surface of the foundation area will be thoroughly scarified before placement of the embankment material.

The cutoff trench shall be excavated to the lines and grades shown on the plans and shall be backfilled with suitable material in the same manner as specified for earth embankment. The trench should be kept free of standing water during backfill operations.

Existing stream channels crossing the foundation area shall be sloped no steeper than 1:1 and deepened and widened as necessary to remove all stones, gravel, sand, stumps, roots, and other objectionable material and to accommodate compaction equipment. Such channels shall then be backfilled with suitable material as specified for earth embankment.

The pipe conduit barrel shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed around the conduit in layers and each layer shall be thoroughly compacted.

The completed spillway excavation shall conform to the lines, grades, bottom width, and side slopes shown on the plans as nearly as skillful operation of the excavating equipment will permit.

All borrow areas outside the pool area shall be graded and left to such a manner that they are well drained.

The material placed in the fill shall be free of detrimental amounts of sod, roots, frozen soil, stones over 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately horizontal layers of such thickness that the required compaction can be obtained with the equipment used. The construction equipment shall be operated over the area of each layer in a way that will result in the required compaction. Special equipment shall be used when the required compaction cannot be obtained without it.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow areas to the extent practicable under prevailing soil and climatic conditions. The embankment and spillway shall be fenced where necessary to protect the vegetation.

Seedbed preparation, seeding, fertilizing, and mulching shall comply with technical guides.

Excavated Ponds

The completed excavation shall conform to the lines, grades, and elevation shown on the plans as nearly as can be achieved by skillful operation of the excavating equipment.

Embankment and Excavated Ponds

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Fencing and vegetation to control erosion and pollution shall be established as needed.

Safety measures, such as warning signs, rescue facilities, fencing, etc. required due to location and use will be planned for.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

POND SEALING OR LINING
Flexible Membrane

Subgrade Preparation

The area to be lined shall be drained and allowed to dry until the surface is firm and will support the men and equipment that must travel over it during installation of the lining.

All banks and fills within the area to be lined must be sloped not steeper than 1 to 1 for exposed lining and 2 1/2 horizontal to 1 vertical for buried linings.

The foundation area for flexible membrane linings shall be smooth and free of projections that might damage the lining. Stumps and roots shall be removed. Rocks, hard clods, and other such material shall be removed or shall be rolled so as to provide a smooth surface or shall be covered with a cushion of fine soil material.

Where needed an effective sterilant shall be applied to the subgrade at the rate recommended by the manufacturer.

An anchor trench shall be excavated completely around the area to be lined at the planned elevation of the top of the lining. The trench shall be 8 to 10 inches deep and about 12 inches wide.

All lining material shall be free of damage or defect. Each package delivered to the job site shall be marked with the name of the material, the manufacturer's name or symbol, the quantity therein, and the thickness or weight of the material.

Placing the Lining

Membranes shall be carefully spread over the subgrade so they lie in a relaxed state. Polyethylene film requires about 5 percent slack for satisfactory results.

All field splices shall be made in accordance with the manufacturer's recommended technique, using materials furnished for the purpose. The joints shall be watertight and maintain its integrity through the expected life of the lining.

Approximately 8 inches of the top of the lining shall be placed in the anchor trench and anchored with compacted backfill.

For covered membranes the material to be used for protective cover shall be free of large clods, sharp rocks, sticks and other objects that would puncture the lining. The cover shall be placed to the specified depth without damage to the membrane.

The test for soil burial will be as follows:

The soil burial test shall be performed by preparing six 6-inch long by 1-inch wide test specimens, 3 in machine direction and 3 in traverse direction, as done for tensile strength testing ASTM D 882B, and bury them vertically to a depth of about 5 inches in soil rich in cellulose destroying micro-organisms. At the end of 30 days, the tensile strength and ultimate elongation shall be determined. The soil used for specimen burial shall be composted soil prepared according to usual greenhouse practice and should have a pH of 6.5 to 7.5. The moisture content of the soil shall be maintained between 25 to 30 percent on an oven-dry basis. The test shall be performed with the soil containers stored in a room maintained between 90 to 100°F. The microbiological activity shall be frequently checked by burying untreated 10-ounce cotton duck for one- and two-week periods. Satisfactory activity is indicated by tensile strength losses above 70 percent of strength in one week and above 90 percent in two weeks.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

POND SEALING OR LINING
Soil Dispersant

The area to be treated should be cleared of all vegetation and trash and all stones or other objects of a size to interfere seriously with the operation of compaction equipment.

The moisture content of the soil should be near optimum for compaction.

Sealing chemicals should be distributed evenly over the surface to be treated with a drill, seeder, fertilizer spreader, or by hand broadcasting. If broadcast by hand, the area should be staked or otherwise marked in grids of 100 square feet.

The chemicals should be thoroughly mixed into the 6-8 inch layer of soil being treated. Mixing should be with disk, rototiller, pulverizer or similar equipment. A second mixing should be carried out in a direction perpendicular to the first mixing.

Water should be added by sprinkling during the mixing operation if moisture is not adequate for maximum compaction. If moisture content is too high, the soil should be dried by disking or some other effective process.

Each treated layer of soil should be compacted to a dry density of 90 percent or more of maximum standard Proctor with soil at optimum or slightly higher moisture content.

Treated areas should be protected from puncture by livestock trampling. Areas near the normal water line and at points of concentrated surface flow into the pond should be protected against erosion.

Sediment coagulating chemicals such as gypsum or iron sulfate should not be used to clear reservoir water after treatment.

Construction will be carried out in such a manner that erosion and air and water pollution will be minimized. The completed job shall present a workmanlike finish.

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SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

POND SEALING OR LINING
Bentonite

The following items should be considered:

1. The area to be treated shall be drained and dried.

2. All vegetation, trash, stones, and other objects of a size to interfere seriously with the operation shall be removed.

3. Holes shall be filled.

4. Sealing material shall be distributed evenly over the surface.

5. For mixed layers, the material shall be thoroughly mixed to the specified depth with disk, rototiller, or similar equipment.

6. Each treated layer shall be compacted to a dry density of 90 percent or more of maximum standard Proctor with soil at optimum moisture content.

7. Treated areas shall be protected from puncture by livestock trampling. Areas near the water line and at points of concentrated surface flow into the pond should be protected against erosion.

Construction will be carried out in such a manner that erosion and air and water pollution will be minimized. The completed job shall present a workmanlike finish.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

POND SEALING OR LINING
Cationic Emulsion - Water-Borne Sealant

The area to be treated shall be cleared of vegetation and trash. If practical a soil sterilant should be applied to the soil prior to the application of the sealant. Water to be treated must not contain suspended sediment in amounts sufficient to coagulate the waterborne sealant. Dry or newly constructed ponds should be thoroughly mechanically compacted.

The sealant material shall be inspected before use. Containers shall be checked to see if any asphalt has settled out. If settled asphalt cannot be easily remixed or if there are lumps of asphalt in the emulsion it shall not be used.

In dry structures the sealant should be added at a uniform rate to the incoming water while the pond is filling, so that all sealant is added and mixed when the pond is filled. During treatment, the pond should be filled to 6" to 12" above normal operating level.

If the pond is full, the sealant may be pumped or poured into the water at intervals around the periphery. However, the sealant must be thoroughly mixed and dispersed in the water immediately after adding the sealant, by some suitable means such as circulating the water in the pond with a large-volume pump. A 72-hour residence time should be allowed for the sealant to deposit out on the underlying soil. A water level of 6" to 12" above operating level should be maintained during the residence period.

The pond should be kept full of water after treatment to prevent weed growth, drying, and weathering damage to the treated surface.

Treated areas should be protected from mechanical damage such as puncture by livestock trampling and from plant growth through the treated surface. Areas near the waterline and at points of concentrated surface flow should be protected against erosion.

Sediment coagulating chemicals such as gypsum or iron sulphate should not be used to clear pond water after treatment.

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SPECIFICATIONS GUIDE

PUMPED WELL DRAIN

Alignment

Drilled or driven wells shall be round, plumb, and so aligned as to permit the satisfactory installation and operation of such pumping equipment as is to be inserted in the well.

Well Development

The well shall be developed until it has ceased to produce detrimental quantities of sand and until the continuous discharge rate is 20 percent greater than the anticipated normal production rate.

Well Record

As construction progresses, the contractor shall keep an accurate well log of the types of materials encountered and the depths at which they are encountered, the depth and thickness of the water bearing strata, progress in sinking the casing, the static water level, and the maximum drawdown. He shall also keep an accurate record of development and test operation.

Reference: Tentative ASAE Recommendation, ASAE R 283(T), "Designing and Constructing Water Wells for Irrigation," is a useful reference in preparing construction specifications.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

RECREATION LAND GRADING AND SHAPING

Special attention will be given to saving and maintaining key trees and other vegetation that has scenic value, provides shade, reduces erosion and runoff, provides den and food for wildlife or that adds to the aesthetics of the area.

Special features to control erosion and handle increased runoff will be incorporated as required.

Safety features considering use to be made of the area will be planned for.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits. The completed job shall present a workmanwork finish.

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RECREATION TRAIL AND WALKWAY

Planning and layout will be done recognizing good aesthetic principles.

Special attention will be given to saving and maintaining key trees and other vegetation that has scenic value, provides shade, reduces erosion and runoff, provides den and food for wildlife or that adds to the aesthetics of the area.

Safety features considering use to be made of the area will be planned for. These could include such things as signs, guard rails, safety fences at key locations, removal of existing fences, etc.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish.

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ROCK BARRIER

Consideration shall be given to the following:

1. Construction shall begin with the top barrier.
2. A vertical cut equal to one-half the height of the barrier shall be made along the stake line.
3. Topsoil shall be stockpiled for spreading on the surface of the bench as construction is completed.
4. Foundation for the barrier shall be shaped so that the full base width is smooth and uniform.
5. As the barrier is built, the area behind it shall be kept filled with soil.
6. The area above the barrier shall be smoothed to design cross slope and the drainage ditch constructed according to plan.
7. Topsoil shall be spread over the completed bench.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

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SPRING DEVELOPMENT

All loose rock, sediment, travertine, logs, and vegetation that obstruct the free discharge of the spring shall be removed and disposed of so that it will not endanger the spring development.

Collection trenches, drain tiles, perforated pipe lines, sumps, and spring boxes shall be constructed to the elevations and grades shown on the plans.

Crushed rock or gravel for collection systems and sand-gravel material for filters shall be composed of clean, hard particles.

Construction operations will be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

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STREAMBANK PROTECTION

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Special attention will be given to protecting and maintaining key shade, food, and den trees and to stabilization of disturbed areas.

Removal of any trees and brush required will be done in such a manner as to avoid damage to other trees and property.

Disposal of trees, brush, and other material will be done in such a way as to have the least detrimental effect on the environment.

Construction operations shall be carried out in such a manner that erosion, and air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

STREAM CHANNEL STABILIZATION

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Special attention will be given to protecting and maintaining key shade, food, and den trees and to stabilization of disturbed areas.

Removal of any trees and brush required will be done in such a manner as to avoid damage to other trees and property.

Disposal of trees, brush, and other material will be done in such a way as to have the least detrimental effect on the environment.

Construction operations shall be carried out in such a manner that erosion, and air and water pollution will be minimized and held within legal limits.

The completed job shall present a workmanlike finish.

SOIL CONSERVATION SERVICE

ENGINEERING SPECIFICATIONS GUIDE

TERRACE, BASIN

A protective cover of vegetation shall be established on all exposed surfaces of the channel, ridge, and borrow areas to the extent practicable under prevailing soil and climatic conditions. Seedbed preparation, seeding, fertilizing and mulching shall comply with technical guides.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized.

The completed job shall present a workmanlike finish.

SOIL CONSERVATION SERVICE

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TROUGH OR TANK

The foundation area shall be cleared of all material not suitable for the subgrade.

The foundation area and the immediately surrounding area shall be smoothed and graded to permit free drainage of surface water.

All materials, placement, anchoring, proportioning, and protection shall be as shown on the plans.

All backfill for underground pipes shall be compacted to the degree required to prevent caving subsequent to construction.

All construction shall be performed in a workmanlike manner and the job site shall have a neat appearance when finished.

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ENGINEERING SPECIFICATIONS GUIDE

WATERSPREADING

Ditches, dikes, and diversions shall be constructed to the planned alignment, grade, and cross section. The finished section shall be generally smooth and of good appearance. Where native vegetation is involved in the waterspreading plan, care shall be taken to prevent undue damage to it by construction equipment.

All related structures shall be located as shown on the plan or as staked in the field. Finished structures shall reflect good workmanship and be completed to meet the requirements of Soil Conservation Service standards for the structures involved.

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